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SCHOOL SCIENCE AND MATHEMATICS

JUNE 1955

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

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If we work on marble, it will perish; if on brass, time will efface it; if we rear temples, they will crumble into dust; but if we work upon immortal minds, and imbue them with principles, with the just fear of God and love of our fellowmen, we engrave on those tablets something that will brighten all eternity.—DANIEL WEBSTER.

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SCHOOL SCIENCE AND MATHEMATICS

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WHY NOT MAKE SCIENCE YOUR CAREER?

RAY WENDLAND
North Dakota State College, Fargo, N. Dak.

It is a strange commentary on current affairs that this astonishing age of scientific explorations and achievements (along with its endless mechanical, electrical, and chemical gadgets) has not drawn swarms of eager youth into the fold of such romantic adventure.

Consider for a moment some of the amazing triumphs of theoretical and applied science during the last two decades, i.e. in the short life span of a recent high school graduate or of one half-way through college:

1. The release of nuclear (atomic) energy and with it the tapping of the supreme power sources of the Universe. That this vast energy is being brought under control for non-destructive peaceful purposes is just as phenomenal as its original discovery.
2. The creation of synthetic textile fibers and rubber—to mention but two of a host of "synthetics" ranging from fertilizers to explosives and anesthetics to vitamins.
3. The perfection of electronic communication devices so that hundreds of messages can be carried simultaneously through a single cable or on a single radio beam. Along with this follows the miracle of television, wondrous even in black and white, and almost unbelievable in color!
4. The development of remote control systems by which complicated machines can be operated at great distances, for instance, aircraft sailing through the night, or guided missiles leaping to the attack of enemy invaders during war time.
5. The development by industry of continuous operating processes which run for weeks and months without end, chewing up a steady

stream of incoming raw materials and producing finished products out of a maze of automatic operating furnaces, reactor tanks, stills, filters, extruders, spinnerets, rollers, and what not.

One would think it inevitable that these marvels of scientific progress would fire up the enthusiasm of our teen age citizens and their parents and teachers. (Instead, we are taking them already for granted, almost as though Heaven owed us a bonus for good behavior, or for diligent pursuit of intellectual and spiritual enlightenment! Even simpler is to accept the marvels and dismiss the complications with a well-worn phrase "What won't *they* think up next?") But something has gone wrong. Young citizens, reflecting on their future careers, are *not* swarming into the sciences for adventure and opportunities for advancement. In fact, the numbers entering are nowhere near equal to those required by the advancing industries, the military forces, research institutes, and by colleges and universities which must always train the youth, while maintaining the spark of eternal search for new knowledge.

To ask the question then "Why Not Make Science Your Career?" is to admit that many people intentionally have chosen *not* to enter science, or have completely ignored the opportunities available.

Let us try to list the reasons we hear about, or can pry out of people when they avoid science and choose something else for a career. And after each reason let me try to give a reply or counter-argument.

Comment 1. Science is only for geniuses or other "odd" characters who dream and scheme and have little interest in the every day affairs of life.

Reply: Naturally, genius helps in any field. Consider what Shakespeare has done for drama, what Mozart, Beethoven and Wagner have done for music, Pasteur for control of disease, Newton and Einstein for physics. But great human accomplishments require not only the work of geniuses but willing followers who patiently put great principles to practical use with skill and intelligence. As for "odd" characters, they are found in every field and science has no monopoly on them. In fact they sometimes add the flavor of variety to an enterprise that might otherwise be a bit dull. So long as they are law abiding and honorable citizens, let them be.

Comment 2. I'm smart enough all right for science, but I'm a *practical* man and don't want to spend a lot of time on theoretical things. I'm in a hurry to get to the top, and when I am there, I'll hire all the scientists I need.

Reply: Fine, You have a healthy ambition! But just wait a minute. You may need more theory at the top than you can imagine right now. And while you are running up hill, don't be surprised to find

yourself in stiff competition with a lot of those "theory" fellows, like chemists, chemical engineers, physicists, geologists, etc.—many of them with doctor's degrees at that! Practical industry is looking more and more to scientifically trained men for its top management.

Comment 3. Science is too hard. What's the use of going to college until I am 25 or 26 years old, study like heck, not have any fun (?!), and wind up with a big debt over my head? There are easier ways to make a living, and I can start earning right now when I'm 18.

Reply: Yes, science is hard, but when you are young, hard work hurts you less than when you are old. Incidentally, many jobs that are mighty hard (or impossible) *without* science become easy with the right application of basic science. Besides, even when you are as "old" as 25 or 26 years, you still have about 40 years of active life ahead of you, and those years spent at skilled work will bring greater end rewards than a larger number of years at lesser skills. And if you are to be really good at anything, whether farming, banking, investments, bossing a production group in a factory, or designing highways, you will find there's a fair amount of work and study to do.

Comment 4. Science doesn't pay very well. I'm going places and I need plenty of cash. Those fellows in the lab can't afford the things I need.

Reply: Well, Sir, some jobs do pay more than others, and generally, the *successful* man who works for himself is better off than one employed by another. But you ought to remember there are many *unsuccessful* people working for themselves, and their pay is certainly not good. Often times those jobs paying the very highest, like acting and entertaining, have the longest waiting lists of unemployed. You might consider that scientists are quite steadily employed, and are in great demand. For instance chemists graduating from college are receiving industrial and governmental offers at the following levels:

With bachelor's degree	330–400 dollars per month
With master's degree	400–460 dollars per month
With doctor's degree	500–600 dollars per month

These payments generally increase 50–60 per cent for ordinary satisfactory service in ten years. Outstanding individuals in industry will double and triple their base salaries by age 40. Those good enough for top management will forge ahead steadily into the top pay brackets with the six figure numbers.

Comment 5. I would like to be a chemist or chemical engineer, but I don't want to spend the rest of my life in the laboratory. I want to get out and see the world, so I better stay out of chemistry.

Reply: Fine, industry needs fellows like you too. Sure, you'll spend several years in the laboratory or in pilot plants learning how things get done. But did you know that chemists and chemical engineers frequently become plant operators, that they may be called into foreign lands to lend their "know how" to plant development nearly any place in the world, that industries require high grade technical salesmen to put across technical products, and that many chemists and engineers move to the front offices to take over top management of large industries? No, a chemist does not need to spend the rest of his life in the laboratory, and the same goes for all other kinds of scientists. If they have any managerial talent, their technical training is no liability, but an asset in their advancement.

Comment 6. I'm a girl, and science has no place for me. A girl doesn't have much of a chance in that business. The bosses figure a girl can't do the work, so they won't hire her—or won't pay her as well as the men.

Reply: Nonsense! If you have what it takes, namely mental capacity, you'll do all right. And if you are one of those lucky "geniuses," there is no better place to show it than in science. (Also, please do not forget that the gentleman scientists oftentimes like to have some feminine charm around them, too.)

Aside from these reasons, women are valued in industry for their dexterity and for their patience with many assignments requiring careful attention and frequent repetition. Many women go into scientific library work (one of the newest professions) and into technical writing and advertising. In addition, medical technology is a vast field for sciences of all kinds, depending largely on women for intricate tests, measurements and treatments in the battle against disease to save human lives.

Comment 7. I like science and am doing all right in college. But I understand that research or teaching in science demands a master's degree at least, and practically a doctor's degree. I just can't stay in school three or four years more after college because I could never afford it. Besides, I want to get married when I graduate.

Reply: You are quite right on the first point and mostly wrong on the second; graduate work in science need not cost you anything except your time and energy. Large sums of money are available to graduate students in the major universities, especially in chemistry, physics and engineering. These sums are in the form of teaching assistantships, research appointments, and outright grants. Teaching assistantships and research appointments generally pay 800 to 1800 dollars per school year, depending on the standing of the

student and the amount of time he can devote to the project. Thousands of graduate students live on these payments, and I would guess that a third of them are married too.

Comment 8. I have heard that science requires a lot of imagination and some handiness with mathematics, too. I can't seem to understand things that I can't see and handle. Theories don't make sense to me.

Reply: Your argument is indisputable. Science indeed puts a high premium on imagination and ability to deal with unseen things. Mathematics establishes exact relationships among the basic things of chemistry and physics, like forces, gravity, work, energy, power, heat, light, electricity, chemical action, and the connection of chemical structure with behavior. If one cannot deal with these things, mostly unseen (but very real!), then he certainly should stay out of science as a career. However, he should never give up trying to learn just a little more about these things, simply because they are fundamental in the universe, and therefore, important to everyone.

In concluding, let me say that Science becomes a *career* to a scientist because he finds enjoyment, satisfaction and real fun working with the things of which the World is made. If he works expertly, he cannot fail to discover something new. This is the basis for what we call exploration, research and adventure into that which is still unknown. And with exploration goes *invention*, the putting together of things familiar (and some things unfamiliar) into an ingenious combination not ever thought of by anybody else. Inventions are aimed at doing old jobs better or easier, or tackling new jobs that could never have been done before a real life inventor had come along with a bright idea. Oftentime inventions are for sheer amusement, and that is all right too.

But let us not assume that Science, pure or applied, has the answer to all things. Science is a kind of knowledge about the world of chemical, physical and biological substances. This knowledge helps man to satisfy his curiosity about the things around him, and above all, to master his environment which for the most part is hostile to him, being too hot or too cold, too dry or too wet, and inhabited not only by great monsters but also by little ones that get under his skin and make him sick or cause his death. Science helps to ease this harsh struggle for survival by providing good food, clean water, shelter, fuel, clothing, transportation and communication. But while man is thus mastering his environment, he must *liberate* himself, and not enslave himself and his neighbors in the labyrinth of mechanization and war. This liberation of man requires the *humane* studies as well,

the humanities and religion which aim at spiritual refinement. This is why we like to say that a true scientist is more than a technically trained man, or woman. He should in the best sense be *liberally* educated, and this means continuing education during a whole life time.

AN APPLICATION OF DUODECIMALS

H. D. LARSEN
Albion College, Albion, Mich.

The short method of reducing feet and inches to inches probably is well known. Thus, 7′5″ may be reduced to inches as follows.

Write 7′5″ as a numeral:	75
Multiply the number of feet by 2:	14
Add:	89

$\therefore\ 7'5'' = 89''$

Again,

Write 13′9″ as a numeral:	139
Multiply 13 by 2:	26

$\therefore\ 13'9'' = 165''$

The proof of this method is a nice exercise in elementary algebra.

The inverse operation of reducing inches to feet and inches perhaps should not be classed as a short method, but it does provide an interesting application of duodecimals. The method consists of a multiplication by 2 and a subtraction in the scale of twelve. Thus, 98″ may be reduced to feet and inches as follows.

Think of 98 as a duodecimal:	9′8″
$9\times 2 = 18 = 1'6''$:	1′6″
Subtract:	$98'' = 8'2''$

Again,

Write 152″ as a duodecimal:	15′2″
$15\times 2 = 30 = 2'6''$:	2′6″
Subtract:	$152'' = 12'8''$

The reduction of pounds and ounces may be treated in a similar manner. In this case, the multiplier is 6 and the scale is 16.

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The Sheraton-Cadillac Hotel in Detroit is one of the finest and most comfortable homes away from home to be found anywhere in the World.

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number of double rooms accommodating three at $5.00 each and/or four at $4.00 each.

You can bring the family this year. There will be no charge for children under fourteen in the same room with their parents. If the children are in a separate room, there is a half charge for the extra room.

You just cannot match your 1955 Convention hotel deal—the fairest rates in the finest hotel.

Your Detroit friends will be looking for you November 24–26 this year in the Sheraton-Cadillac Hotel.

EDUCATIONAL TELEVISION AT I.U.

Education television programs will be made available for 16 mm use by adult and other groups through an arrangement just completed between Indiana University and the Educational Television and Radio Center (ETRC), Ann Arbor, Mich. Distribution will be handled by the National Education Television (NET) Film Service. NET will be a part of the Audio-Visual Center of Indiana University headed by L. C. Larson.

Under terms of the agreement, NET Film Service will serve as the national center for non-television distribution of educational programs material produced by the ETRC. Programs will be distributed on a rental and a on sale basis. The Film Service will be a non-profit operation.

NET will seek to identify adult groups that can employ films and kinescopes developed by the ETRC, acquaint these groups with the availability of such materials, and promote their use by adult groups. The Film Service will maintain a distribution organization that will provide service on a local, national, and regional basis; assist adult groups in improving their selection and utilization of materials; and conduct research related to the 16 mm distribution use, and influence of program materials produced by the ETRC.

Program content will be concentrated in the areas of political, social, and literary heritage of the United States, contemporary America, international affairs, the individual and society, the world of science, the fine arts, and children's programs. Most programs will run 29 minutes. At present all programs are black and white.

Inquiries about the availability of programs for non-television use should be addressed to NET Film Service, Audio-Visual Center, Indiana University, Bloomington, Indiana.

BELIEVE IT OR NOT

The first teacher exchange program between the U. S. and another nation was begun in 1908 at the *request* of the Prussian Ministry of Education to the Carnegie Foundation for the Advancement of Teaching in America. Under the sponsorship of the Foundation, the exchange program continued successfully up to the beginning of World War I. Prussian teachers coming to this country were to offer supplementary instruction and not to take the place of regular teachers. American teachers going to Prussia were to instruct students in English, also informally. The inauguration of the exchange precipitated a discussion in German and English periodicals as to whether American teachers were actually fit to teach the English language. (Source, 3rd Annual Report, Carnegie Foundation for the Advancement of Teaching, pp. 47–49).

HELPING THE SLOW-LEARNER IN MATHEMATICS

HAVERLY O. MOYER
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The opportunity to work with a slow-learning group in mathemathematics is a revealing experience. Of the many problems involved in helping the slower learner to grasp mathematical concepts two seem most crucial. The matter of *meaning* and the matter of *security* appear to be the ones most difficult to provide for. If children are not given meaningful mathematical experiences, they are likely to become more and more confused and more and more insecure as time goes on.

Probably most teachers of junior high school children find in their classes some pupils who have some ability to do mathematics in a mechanical way if they happen to follow the right formula or choose the right fundamental process but who do not actually understand the rationale for their computations.

The questions and behavior of these children usually indicate a lack of security and an uncertainty about the meaning. They ask, "Shall I multiply?" looking intently at the teacher with concern. If they see the slightest flicker of disapproval on the teacher's face, they quickly change to, "Divide?" Or they sometimes exhibit indications of tension such as biting nails, muttering, squirming, constantly asking for help and even weeping or withdrawing. None of these are conducive to learning and retaining useful mathematic information.

What can we do with these children? First, let's take every opportunity to improve their security, by letting them know that we see and approve of their strong qualities and by encouraging them to try. Then, let's ask ourselves if we are putting too much importance on the necessity for learning the material of mathematics. Do we believe that no one will be a successful person if he isn't quick in mathematics? Perhaps we are demanding too much too soon. Second, let's ask if we are expecting these slow learners to grasp abstract concepts without a concrete, meaningful basis. If we answer those two questions honestly and carefully, we will then do some of the following things: make the children comfortable, find every possible way to point out to them the things they *can* do, discover their individual level of mathematic ability and begin there, go slowly, stop work shortly after the first signs of tension, work with real problems, choose simple problems at first, praise every successful experience.

A description of an actual slow group's experiences may clarify. There were four pupils in the slowest group of an upper grade. Two were boys and two were girls. All were sure they couldn't do mathematics. One girl and one boy had decided, "I just can't do it." One

girl tried but she was so convinced that she couldn't get the right answer that she grasped at any process, then worked so fast, tensely and nervously that she nearly always made an error in computation even when she had guessed the right process. One boy would start off quite well but "give up" before the problem was finished. He usually knew what to do in a mechanical way but didn't know why he was doing it. Their experiences with mathematics had apparently been uninteresting, and impractical to them.

This is what the teacher did when he began work with this group. They were struggling with finding areas of rectangles. They appeared to know the formula and could do the accompanying examples in the text with the correct process but seldom got the right answer because of computational errors. When they were asked to find the area of the tops of their desks they appeared to see no relation to the previous book work. Their teacher then gave each pupil a sheet of paper a foot square and asked them to mark off each side in inches, then connect the dots. Finally each child was asked to number each inch square. They discovered that they had 144 square inches. They *saw* what they had memorized abstractly.

"Now," asked the teacher, "can you find an easier way to find the number of square inches in a square foot than counting?" They did after some experimenting.

Later the teacher gave them a rectangle which they divided into square inches and numbered. They discovered what their formula meant. They did many simple problems such as finding the area of the desks, the teacher's desk, the work table, the windows, the floor. During this period of careful work with simple areas the teacher was doing other things of equal importance. He made it a point to find time each day to talk with each pupil about his interests. He found out what things each pupil could do well and gave him opportunity to do something about one or more of them. He tried to free each pupil from worries about poor work in mathematics and he gave some time to simple, practical number experiences that the children met daily such as keeping the book store record, having charge of lunch money, buying mirrors for a periscope, and planning the cost of a class trip. These experiences were intended to release these children from fear and begin building confidence, confidence strong enough to give the pupils courage to try and stability enough to insure more careful procedure and more accurate computation.

One day they wondered how many blocks of linoleum were used in the corridor floor. One said, "Just multiply the number of blocks wide by the number of blocks long." Another insisted it wouldn't work because the blocks were not a foot square. They measured and found that it was true. Finally one of the boys pointed out that they weren't trying to find number of square feet, they were trying to find

number of square blocks. When that idea was accepted, they talked about procedure. The boys decided the best solution would be to count the blocks "long" and the blocks "wide" and then multiply. The girls thought they could do it faster by counting all the blocks thus eliminating the possibillty of an error in multiplying. When they discussed how they would know if they had the right answer, they decided that they would consider their answer correct if they got the same answer twice consecutively and the answer of the girls checked with the answer of the boys. The teacher did not interfere with that decision, because it did not seem to be the appropriate time to discuss that aspect of the problem.

Since they were working with a problem of their own, since it was concrete, since they knew what they were trying to do; there were no signs of tension, they worked more carefully, they concentrated completely, they paid no attention to the people who stopped in the corridor to watch them, they seemed happy.

The girls counted the blocks three times before they got two consecutive answers that were the same. The boys got the same answer the second try. They were pleased and proud when the answers of the boys checked with the answers of the girls. Since the boys finished long before the girls, they were convinced that counting is much too slow a process for finding the area of a rectangle, either in terms of blocks or square feet.

The small success in this problem gave them courage to try others, many of their own making.

The story does not end here with "they lived happily ever after" or "they learned easily ever after" propaganda. On the other hand, it was frequently necessary to review practical problems of finding area and for some time any attempt to solve abstract or book problems demanded a return to a recall of the process used to discover the real meaning of *area*. After many experiences of that kind, the children would see a similarity between the new problem and their original diagram (which, incidentally, they kept after the teacher had resorted to the device of marking off square inches and counting for the third time).

Finally, whenever there was any doubt about an area problem, the teacher would suggest drawing a picture of "what it says to do." That would usually give insight and help the children to a solution.

These pupils gradually became more accurate. Their comprehension increased, their attention span grew longer, they gained in confidence and stability. Since it would take far too long to relate all the experiences, the successes and failures, the ups and downs; several chapters of the story will be omitted to give a glimpse of these children near the end of the school year.

The teacher brought a cylindrical pail and asked these pupils if

they could figure out mathematically how many gallons of water it would hold. They decided they would need to know how many cubic inches in the pail. Then they would need to know how many cubic inches in a gallon. They decided that they could find the number of cubic inches in a gallon for themselves if they had a rectangular maple syrup can. When they measured a can and computed, their answer was 230+cubic inches; then they verified that answer by checking their books. Some time was given to talking about the reasons for not getting the exact answer given in the texts and other reference books. A discussion followed on the meaning of accuracy.

When the children were led to see that there was a possible similarity between finding the volume of the syrup can and the cylindrical pail, they deduced that it would be necessary to find the area of the bottom of the pail, first, then multiply by the height. Since they had learned to find the area of a circle, they had no difficulty in deciding to find the diameter of the bottom and proceed. One pupil cautioned the others to measure the inside of the pail to get the exact diameter of the space where the water would be put. Another obserced that the pail would probably not be filled to the exact top and decided to allow one half inch on her height measurement.

They computed the area of the bottom of the pail and compared results. It was a satisfaction to see their faces when they all had the answer. Then they worked independently on the next two steps. Namely, to multiply the area of the bottom of the pail by the height to get the volume and divide by 231 to get the number of gallons.

At that point the teacher suggested that they take their books and verify each step. After they did that, the pupils suggested that they should verify their answer by filling the pail with water by using the syrup can. This they did. They were excited and happy to find their answers were right.

So another problem led them to see more fully that a mathematical solution can be a short cut to the answer for a concrete problem. Again it was a problem that provided immediate knowledge of results, developed real understanding, increased confidence and built stronger interest in mathematics.

This was a rather long and difficult problem for a group of slower learners. The fact that they succeeded was not such an important achievement mathematically but it was most important from the standpoint of the change in attitude about mathematics. It is quite likely that none of this group would remember how to find the area of a circle or volume of the cylinder over the summer vacation but all four had a different concept about themselves and a different feeling about mathematics.

At the end of the year they still needed to improve in accuracy, in

speed, in comprehension but they did have more confidence, more hope of succeeding, more courage to try, more understanding of relationships, more insight into mathematical concepts and a liking for a subject that had been frustrating.

Meaning and *security* are two of the essential features of a good learning experience for slow learners. There is no formula for the teacher that will assure success with all slow learners. Every teacher must devise his own ways of making mathematics meaningful and giving security and confidence to those pupils who have not been successful in their number experiences.

A SCHOLARSHIP FUND IN RECOGNITION OF E. LAURENCE PALMER

We have many reasons to believe that you share our deep interest in nature study, science teaching, and conservation education. Among these reasons is your evident interest in and active work toward goals similar to those sought by Dr. E. Laurence Palmer.

When Professor Palmer retired on June 30, 1952, his former graduate students established a scholarship fund in recognition of his many services. The fund now has slightly more than $1,000.00 as the endowment. This makes available at current interest rates an award of somewhat more than $40.00 a year. This is awarded as a scholarship to some graduate student with interests in harmony with those of Professor Palmer. We believe you would like to help in the growth of this endowment fund so that the scholarship awards may perpetually be a more adequate recognition of Professor Palmer's many and substantial contributions.

Contributions should be made in favor of Cornell University and sent to us. The money will be credited to the proper fund. If you would like a receipt for income tax purposes, we will be glad to see that one is sent to you. Be assured that all of us and graduate students in the future will deeply appreciate whatever you see fit to contribute.

Sincerely yours,
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3 Stone Hall,
Ithaca, N. Y.

The above announcement gives all nature lovers an opportunity to contribute in honor of one of our great men in this field. Dr. Palmer has spent much of his life time in improving the educational opportunities of rural youth in the many branches of elementary science. He taught science as children like to learn it. Not only the children of New York State but many throughout the nation learned the habits of the little people of the plant and animal world through Dr. Palmer's *Leaflet* and his many students, who become their teachers. It is a real pleasure to endorse this project.

GLEN W. WARNER, *Editor*
SCHOOL SCIENCE AND MATHEMATICS

AN ELECTRONIC BRIDGE FOR INDUCTANCE AND CAPACITANCE MEASUREMENTS

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Measurements of circuit elements at certain radio frequencies is possible with the electronic bridge described in this paper. A schematic drawing is shown in Figure 1.

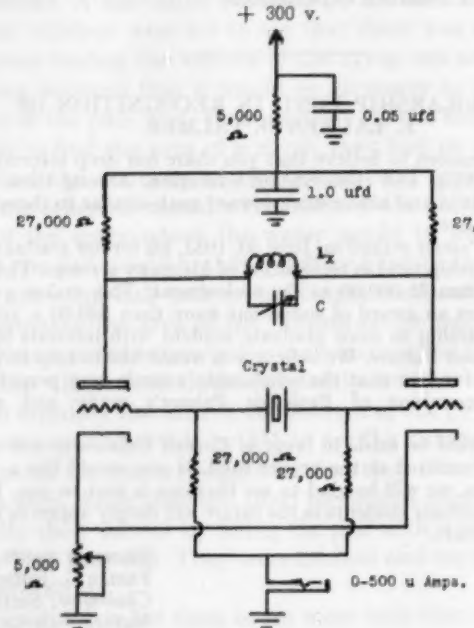

Fig. 1.

Basically, the circuit utilizes the substitution method of measurement and as is true with such a method, the accuracy is determined largely by the accuracy of calibration of the standard capacitor or inductor. Certain features of the circuit permits measurement of inductance and capacitance with a minimum of equipment.

The circuit involves a push-pull crystal oscillator which allows symmetrical placement of the components. The circuit oscillates when the parallel inductance and capacitance are adjusted to the same frequency as that of the crystal. The capacity associated with the crystal and holder becomes charged and discharges through the grid leak resistor. A meter in the grid circuit is thus the indicator of the oscillating condition of the circuit.

The frequency of oscillation being determined by the crystal, then either the inductance or the capacitance can be found from the standard formula, provided the other is known.[1]

With this introduction, certain details of the circuit design will be discussed.

At the resonant frequency of the parallel tank combination, the inductance and capacitance can be thought of as a resistance of an approximate magnitude of QX_L or Q^2R_e. The Q symbol represents the voltage magnification factor of the tank, X_L the inductive reactance of the coil at the frequency of oscillation, and R_e is the series resistance of the coil.

Since an alternating voltage appears across the tank, the tank can be thought of as a resistance and voltage generator. The two triode units are effectively resistances with the unique property of a phase change of about 180°. The crystal can be considered as a series resonant circuit acting as a voltage generator.

The actual circuit, then, has two voltage generators which are synchronized with one another only during oscillation. The voltage generator attached to the grids (the control electrodes) assumes control of the oscillations. The frequency of the oscillation being known, of course, to an accuracy dependent upon the specifications of the crystal.

During oscillation the grids are biased with a negative voltage. This is the result of the average grid current causing a voltage drop across the grid leak resistor. The magnitude of the bias voltage is about equal to one-half the product of the average grid current value and the grid leak resistance value. In the circuit described it amounts to about -6.75 volts for the 12AT7 tube.

The crystal, with its very high Q property, can maintain oscillations over a wide range of L/C ratios in the plate tank circuit. It must be kept in mind, however, that some crystals exhibit low activity and some none at all.

For the 12AT7 tube, and a supply voltage (the output voltage of the decoupling filter) of 240 volts, the actual plate voltage is 120 volts. This is the condition at the adjustment for maximum grid current (minimum cathode resistance). With the 27,000 ohm value for the plate load resistance, this indicates a plate current of 4.44 milliamperes, considering one tube. There is thus about 120 volts of radio frequency voltage at the plate which effectively produces the feedback voltage at the grid that causes the oscillations.

If one allows the plate-grid voltage ratio to be A, then the value of

[1] J. G. Brainerd, Glenn Koehler, Herbert J. Reich, L. F. Woodruff, *Ultra-High-Frequency Techniques*, D. Van Nostrand Co., New York, N. Y., 1942, p. 18.

the ratio (using Coil X of which more will be said later) is as follows:

$$A=\frac{E_p}{E_g}=\frac{120}{6.75}=17.8.$$

The plate-grid voltage ratio can be expressed in an alternative fashion, namely:[2]

$$A=uZ_a/(Z_a+R_p)$$

where

u = the amplification factor of the tube
Z_a = impedance of the plate circuit
R_p = internal tube resistance

If one assumes values of 45 and 15,000 for u and R_p (from tube data sheets supplied by the tube manufacturer) for the 12AT7 tube, Z_a calculates out to be about 9,800 ohms.

Inspection of the circuit will reveal that Z_a, the total plate impedance, is actually (at resonance) the result of the plate load resistance and the equivalent resistance of the parallel tank in parallel. Since R_L is 27,000 ohms, R_e (the plate tank equivalent resistance) can be calculated. For the 12AT7 tube, R_e amounts to about 15,300 ohms.

This figure gives an indication of the conditions under which the plate tank is being operated. In order for the grid current maximum to be sharp, the tank must operate with a high Q property. This means that the plate current can flow for only a short interval during one cycle of operations. Since R_e has a magnitude of about QX_L, one can find X_L for the frequency being used, and then find an approximate value of the operating Q. In the particular circuit under discussion, with Coil X having an apparent inductance of 15.1 microhenries at 4.440 megacycles, the inductive reactance is near 420 ohms. With the calculated value of R_e of above, the operating Q figure is about 36.

This result is found in the case of the 12AT7 tube. Other tubes would, of course, set up a different set of operating conditions.

The value of the grid leak bias resistance will have an optimum value for each tube used (that is, about 27,000 ohms for the 12AT7, 100,000 ohms for the 12AU7, etc.). The plate load resistor should be high in comparison with the internal plate resistance, but in the case of the crystal oscillator, the stabillty is enhanced by the use of the crystal. A lower value of the plate load resistance can be used then, in order to keep the static plate voltage about one-half the value of the plate supply voltage (Terman's criterion for the proper operation of an oscillator).

[2] I. E. Mouromtseff, "Tuned-Grid Tuned-Plate Oscillator," *Communications*, August, 1940, p. 7.

The parallel tank operating Q cannot be too low if oscillations are to be easily begun for a large range of inductance and capacitance combinations.

In determining the "apparent" inductance of a coil serving in the plate tank circuit, it is first necessary to determine all the capacitance associated with it. With the tank capacitance calibrated one can next find the capacity associated with the tube used in the bridge. This amounts to the plate to grid capacity of both the triode units. In order to find this, one must have provided in the construction of the bridge two tube sockets with the corresponding grids, plates, cathodes, and filaments connected together. Then two tubes are inserted and a grid current maximum found for a certain crystal and value of inductance and capacity. Then one tube is removed. Additional capacity must be added with the calibrated plate capacitance for a new grid current maximum. The value of the capacitance added will be the capacitance of the tube that is effective in the circuit. The stray capacitance of the bridge must be estimated as it will depend upon the method of construction. The capacity of the wires used to attach the inductance (the plate capacitance should be mounted internally) can be measured by using different lengths of the same wire and noting the increase of capacitance per 6 inches, say.

The tubes that will work in the bridge are the 6J6, 12AU7, 6SN7, 12AT7, 6SL7, and 12AX7. The first four mentioned were found to be the most suitable.

With a selection of crystals, measurement of the apparent inductance of a given coil can be made at a number of frequencies. These values may be then plotted and the operation of the coil over a range of frequencies noted. An example of the apparent inductance variations for two coils is given in Figure 2. One can note that there is an advantage, apparently, in arranging the winding length to be of the same magnitude as the diameter. Coil X has a greater useful frequency range for a given amount of capacitance.

The true inductance as well as the distributed capacitance of the coil may be found with the following:[3]

$$Lt = \frac{1}{C_1 - C_2}\left(\frac{1}{(2\pi f_1^2)} - \frac{1}{(2\pi f_2^2)}\right)$$

where C_1 and C_2 are the plate tank capacitance associated with resonance at the frequencies f_1 and f_2.

The true inductance of the Coil X was found to be about 11.2 microhenries. This was calculated for 4.440 kcs. and 5.555 kcs. and capacitance values of 86 $\mu\mu$f. and 45 $\mu\mu$f.

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[3] Gaylord P. Harnwell, *Principles of Electricity and Electromagnetism*, McGraw-Hill Book Co., New York, N. Y., 1949, p. 472.

The distributed capacitance, C_d, can then be found with the expression:

$$C_d = \frac{1}{(2\pi f)^2 L_t} - C$$

here

C_d = distributed capacitance of the coil
L_t = true inductance
C = plate tank capacity at frequency f

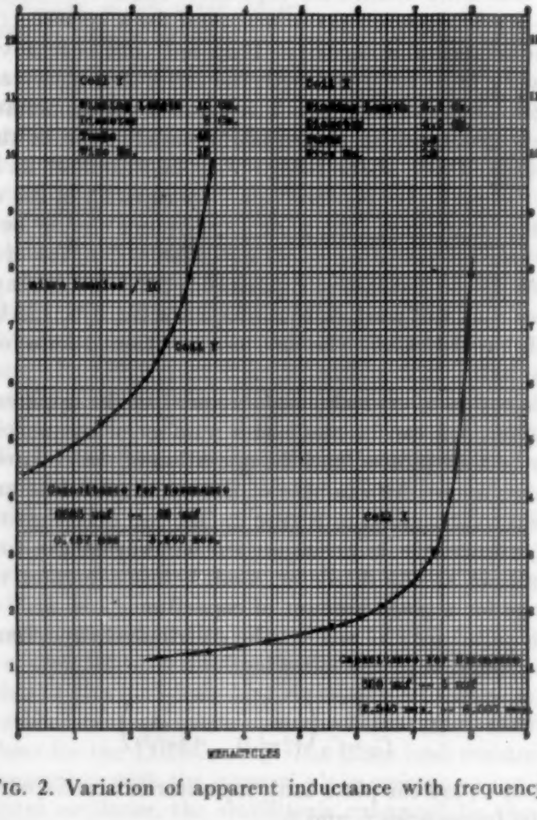

Fig. 2. Variation of apparent inductance with frequency.

The distributed capacitance calculates out for Coil X to be 28 $\mu\mu$f. This corresponds with the observed self-resonance of Coil X (no plate tank capacitance) at 8.666 mcs. Here the inductance of 11.2 microhenries and a distributed capacitance of 28 $\mu\mu$f. will give the resonant condition, when one allows 2 $\mu\mu$f. for the tube and stray

capacitance. The latter is rather a low value for that part of the capacitance, however.

A useful formula for finding the apparent inductance is the following:

$$L_a = \frac{25{,}300}{f^2C}$$

where

L_a = the apparent or operating inductance in microhenries
f = frequency in megacycles
C = capacitance in micro-micro-farads

There are other alternative uses of the bridge. A tank circuit (of which the resonant frequency is unknown) may be inserted in the grid circuit in place of the crystal. If there are available tank circuits calibrated as to frequency, these can be inserted in the plate circuit and the bridge adjusted for resonance (maximum grid current). The plate tank will be tuned, then, to a slightly higher frequency than the grid circuit tank, but for most purposes the two tank frequencies may be assumed equal.

It is interesting to note the behavior of a coil when the frequency is increased to a point where the tank capacitance is reduced to a small value (say below 10 $\mu\mu$f.). Here the distributed capacitance of the coil is the larger and the coil acts similar to a shorted quarter wave line. The equation for resonance in this case can be stated with the expression:[4]

$$Z_0 \tan \frac{2\pi f s}{v} = \frac{1}{2\pi f C}$$

where

Z_0 = characteristic impedance
s = equivalent electrical length
v = phase velocity (when conductor resistance and radiation is low, this is 3×10^{10} cm./sec.)

Here the tangent function is involved and the curve of the apparent inductance becomes similar to a graph of the tangent function as the angle approaches 90°.

Construction and operation of the bridge is not difficult. Small capacitances can be measured if a set of calibrated inductances are available.

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[4] Hugh A. Brown, "Frequency of Capacitance Tuned Lines and Resonant Line Oscillators," *Communications*, May, 1945, p. 52.

DOES YOUR CHEMISTRY COURSE SHOW SIGNS OF LIFE?

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Is there life in the chemistry course you teach? Is chemistry a popular course in high school? If a popularity of the subject exists does the total number taking the course today show an increase, percentagewise, over former years? Or, is chemistry a popular topic of discussion because statistics show those persuing the subject through the colleges are not entering the field of teaching? What can be done to further stimulate interest in the subject? You, as a competent teacher, should know what to teach, how to teach it, and make your course interesting.

There are many items that are taught to students taking chemistry in high school. We find also that those in the field of teaching are not in agreement as to what should be rigidly taught—nor is it necessary for them to be. One teacher may wish to omit "old" concepts of chemistry and make the classwork practical or change all the old chemistry laboratory experiments so that they will be directly related to present every day living. Another teacher may wish to expound on Boyle's law and Charle's law. You might like to omit Avogadro's hypothesis, another may wish to use only fundamental concepts. I may wish to drop the theory of nuclear fission. Again, one may hear it said that the chemistry we have been teaching the past ten, twenty, or even forty years is practical. One might ask, "Isn't the study of water practical? Of air? Of solutions, oxygen, hydrogen, sulfur, ammonia, baking soda? Isn't the study of acids and bases practical?" One teacher may be extreme in one direction and another is extreme in the opposite direction.

Much that has been, and is now being, taught in chemistry is of greater practical value than many teachers seem conscious of. A textbook cannot use the space to list all the practical uses of a substance it mentions. If one were to take the time to look them up one could find from ten to one-hundred present uses for most every compound in the text. Enlightening to the class as a whole is the project of a group of students compiling a list of the uses of some of the compounds, from references, and presenting them. One hundred uses for common table salt, fifty uses for sulfuric acid, forty uses for baking soda, etc., can be found. It is well worth while to stress the importance of these substances from a commercial standpoint. A business motto is "To succeed sell goods of merit and don't be afraid to push them." Chemistry, as a subject for high school pupils, has real merit and chemistry

teachers should not be afraid to "push" their subject. Teachers might do this if some imagination is put into "the old chemistry book" by making some phases of it more personal when bringing it to the class. No one can teach with interest about the air we breathe or the water we drink or the food we eat or the clothes we wear without teaching "live" chemistry. Chemistry textbooks have for years told something about the air which is breathed yet nothing about the air *we* breathe. And all textbooks tell something about drinking water yet little about the water *we* drink. Textbooks relate something about food but nothing about the food *we* eat. That is, it is within the teacher's power to "personalize" some of the parts of the chemistry course. This leads toward interest. And when reaching a particular phase of the course, especially after an amount of theory has been covered, it is intended that students become quite engrossed with the work at hand. To have this come about the student must be in contact with something that holds his interest to the point of wanting to see the "end point." Thus, to learn about the air *we* breathe samples of air from the classroom at the beginning and near the end of the period can be taken and analyzed. This may be done with the Orsat-Muenche gas analysis apparatus. Good results can be obtained for oxygen but it is found difficult to show the carbon dioxide present with the instrument as the percent by volume is approximately 0.04%. However, interest is promoted in the class by analyzing the exhaled breath of several students for comparison. The Walpert air tester may be used to analyze carbon dioxide.

When water is discussed the subject centers around the water *we* drink—its supply, its source, how it is filtered or pumped, liability to contamination, bacterial count, which is demonstrated and observed, whether it is a hard or soft water, whether it is a good drinking water or washing water, its chemical composition and how it compares with an ideal drinking water.

If the subject centers around food a discussion of the chemical nature of the food *we* eat is taken up. For the laboratory work the class is divided into groups. If rigid laboratory procedures are used[1] perhaps here is an opportunity for slight relaxation. Each group will work and complete an analysis of each particular food. One group tests extracts, one milk, one meats, one tests butter, fats and oleo, another tests dried fruits, and another tests vinegars, another ice-cream and candies, and one group tests baking powders. The students work under supervision and make their reports on data sheets. They affix their signature certifying that "To the best of my knowledge and ability the analysis is correct." This places the responsibil-

[1] M. M. Gunkle, "Striving For Individual Laboratory Measurements," *Journal of Educational Research* (December, 1952), Vol. XLVI, pp. 275–84.

ity for a degree of accuracy on the group making a report of the analysis. Analyses of one class may be passed along for comparison to the other classes. This stimulates a competitive interest in striving for accuracy.

Much of the work given in high school the past twenty-five years has tended to develop in the student valuable habits and traits of character, namely, ability to observe closely, think logically, be self reliant, independent, and have confidence in one's ability to do things. Along with these traits valuable practical knowledge is gained.

Of vital importance to high school students is the presentation of the subject of chemistry. It may mean the difference between interest and disinterest. The teacher must remember that the subject is a new field for most pupils in high school and the large amount of theory found in textbooks today must be presented tactfully. It will be difficult for many of them to understand, and some cannot see the use of it all. So many new ideas, and difficult ideas, are introduced in rapid succession that the teacher must use all available resources to make it possible for the student to grasp the meaning of the items. But the fact that a portion of the subject is difficult is not sufficient argument for omitting it. Successful teaching is also difficult. Would you have schools omit it? Success consists of not only doing the things we like to do, but in doing the things we have to do if we are confronted with them. Most adults have been confronted with this issue in life. This is a valuable lesson for the student to learn during his formative years. While we must interest them we are not there to entertain them all the time. One of the difficult tasks teachers contend with is to get the pupil to attack a problem or experiment that requires patience, accuracy, and concentration, and to bring the problem to a successful conclusion. If teachers can stimulate students so as to bring this about in a general way, by using means, new or old methods, new or old ideas, then the contribution to the student has been successfully met.

Herbicide applicator for the home gardener is an aerosol weed killer attached to a walking stick, thus eliminating bending. Spray can be concentrated on a small spot to kill weeds growing next to desired plants. One 12-ounce container on the 28-inch, ball-ahndle stick treats 600 weeds.

Night piercer is an infra-red instrument that enagles the human eye to see great distances in darkness and dense fog. Seen as a safety device for transportation vehicles, the combined infra-red receiving tube and built-in coated lens, was recently taken from under Navy security wraps.

SURVEY OF RESEARCH IN SECONDARY SCHOOL SCIENCE EDUCATION*

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AND

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Introduction

About two years ago the following statement[1] appeared in a journal devoted to research in science education:

> If science teachers were cognizant of the factors which contribute to student achievement, abreast of the current developments in science relative to the objectives of science instruction, and alert to the use of the findings of scientific and educational research, a more realistic teacher training program could result, increasing vitality in the secondary school science classrooms of the nation.

The authors of this report have no argument with the above statement *per se.* Yet, they firmly believe that the implications of this statement apply to all teachers, in all subject-matter areas, and at all levels of instruction. They would also like to point out that to attain such a goal would indeed be a large order for any teacher, especially those in public schools. Few teachers have available all the references and other source materials that contain the needed information. If such materials were available few teachers would have time to read and glean the information from them.

This fact has been recognized by both the American Educational Research Association and the National Association for Research in Science Teaching. The first of the two organizations has for many years published the *Review of Educational Research,* a journal in which reviews of research in certain educational areas appear triennially. One of these issues, somewhat technical in nature, dealt with the Natural Sciences and Mathematics. The last review devoted to these areas appeared in October 1951. Since that time the National Association for Research in Science Teaching has undertaken to produce an annual review of science education to replace that no longer produced by the AERA. The first in this series of review[2,3] ap-

* A report delivered at the 121st meeting of the American Association for the Advancement of Science at the University of California, Berkeley on December 29 to a joint session of the National Association for Research in Science Teaching, the AAAS Cooperative Committee on the Teaching of Science and Mathematics, the AAAS Section Q—Education, and the National Science Teachers Association; co-sponsored by the Western Society of Naturalists.

[1] Anderson, Kenneth E., "Improving Science Teaching Through Realistic Research." *Science Education*, XXXVII (February 1953), 55.

[2] Buck, Jacqueline V. and Mallinson, George Greisen, "Some Implications of Recent Research in the Teaching of Science at the Elementary-School Level." *Science Education*, XXXVIII (February 1954), 81–101.

peared in the February 1954 issue of *Science Education;* the second[4] in a later issue of the same journal. In 1950 there was published another somewhat technical review[5] that supplemented those that had appeared previously. However, many educators were aware that these technical reviews, while suitable for the specialist in science education, ordinarily were not suitable for the typical classroom teacher. Nor were they phrased in terminology easily understood and applied by the non-specialist. Hence, a number of non-technical reviews were produced to meet the need just indicated. Among the earliest efforts was one by Curtis;[6] among the more recent, two by Mallinson and Buck.[7,8]

Yet, it is well-known that the field of science education is fruitful of a vast amount of research for which technical and non-technical summaries are needed frequently. It would seem reasonable therefore that the implications of recent studies should be integrated with those of earlier ones in order to disseminate information by which science teachers may improve science teaching. Such is the purpose of this non-technical summary of recent research in science teaching at the secondary-school level.

As is customary with non-technical summaries, no effort will be made to cite the sources wherefrom the implications emerge. Further, for convenience, studies have been grouped under categories to which they seem logically to belong.

Studies in Science Curriculum

Courses in the Science Curriculum

It is indeed an unhappy conclusion, unavoidable as it may be, that there is a dearth of significant research with respect to the optimal science curriculum in the secondary school. The literature is replete with discussions of the need for a better general-education program of science, as well as for a better specialized program. Further, there are many opinions as to what the curriculum should include. However, there has been no systematic attack via research.

[3] Mallinson, George Greisen and Buck, Jacqueline V., "Some Implications and Practical Applications of Recent Research in the Teaching of Science at the Secondary-School Level." *Science Education*, XXXVIII (February 1954), 58–61.

[4] Anderson, Kenneth E., Smith, Herbert A., Washton, Nathan S., and Haupt, George W., "Second Annual Review of Research in Science Teaching." *Science Education*, XXXVIII (December 1954), 333–365.

[5] Mallinson, George Greisen, "The Implications of Recent Research in the Teaching of Science at the Secondary-School Level." *Journal of Educational Research*, XLIII (January 1950), 321–42.

[6] Curtis, Francis D., Chapter XI entitled "Science" in *The Implications of Research for the Classroom Teacher*. Joint Yearbook of the American Educational Research Association and the Department o Classroom Teachers. Washington 2, D. C.: National Education Association, February 1939, Pp. 318.

[7] Mallinson, George Greisen and Buck, Jacqueline V., "Some Implications and Practical Applications of Recent Research in Science Education." *Journal of Education*, CXXXVII (October 1954), 23–6.

[8] Mallinson, George Greisen and Buck, Jacqueline V., "Science Education Research and the Classroom Teacher." *The Science Teacher*, XXII (February 1955), 20–2.

The recent studies that have undertaken seem to point out that a program of elementary science followed by courses in general science, general biology and general physical science offer a good general-education program for all students through the sophomore year of high school. The specialized courses in chemistry, physics, earth science and advanced biology seem to be the specialized courses offered ordinarily at the junior and senior years of high school.

There seems to be divided opinion as to whether students desiring to work toward scientific careers should start to specialize earlier than the eleventh grade via the two-track curriculum (i.e., one for the specialist; one for the non-specialist), or whether all students should first take the general education courses, the specialist then following with the specialized courses. This latter problem has not yet been attacked. Meanwhile enrollments in science drop while science educators debate rather than investigate.

The Objectives of Science Teaching

It would seem that the many studies that have identified principles, attitudes and skills of science of value in secondary schools would have long since clinched the issue. Yet, during the last year a number of studies have appeared in which principles of biology were again evaluated for their inclusion in biology courses and experiences evaluated for the extent to which they might be used to develop the principles. The same seems to be true for the other areas of science. Apparently the lists of attitudes and skills of science are accepted since no research studies were found that dealt with them.

Unfortunately, most of these studies seemed to consider principles as being statements of biological generalizations, rather than perceptions and understandings to be developed in the student. Further, the topics, experiments and other experiences seemed to be selected because they fall in the same subject-matter pigeon-hole as the principle. Few investigators seemed to consider them as being more than statements to be assigned to principles, rather than experiences in which students may participate with interest and motivation.

A number of studies were undertaken to identify up-to-date experiences and materials that might be used to attain the objectives of science teaching. Ordinarily they have been selected by the jury-technique on the basis of their relationships to the objective in question. Most of these studies seemed to indicate that the "experts" find many topics in up-to-date literature, newspapers and other sources of communication that are related to certain objectives. As a result it is generally concluded that "essential principles, attitudes and skills" can be developed by using these experiences rather than tradi-

tional ones. Apparently the factor of relationship is assumed to indicate a causative influence.

Studies in Curriculum Enrichment

Many studies have appeared in the last year that have been related somewhat to the studies listed in the previous section. These studies have dealt with the enrichment of courses with audio-visual materials, applications from aviation, and materials of conservation. All the studies in this area point to a conclusion made many times before, namely, that teachers may find in many areas other than the traditional ones, materials that are related to the basic objectives of science teaching. All these studies point out the possibility of enrichment of science courses through materials and techniques other than textbooks and lectures. In many of these studies, specific conservation units are listed, syllabi for use of aviation materials are developed and lists of audio-visual materials are presented. While none of these publications are suitable *in toto* for all schools, nearly all can offer something for some schools.

Probably the most obvious conclusion is that only small amounts of ingenuity and effort are needed by science teachers to provide some form of enrichment, if they so desire.

Studies in Learning and Teaching Science

Problem Solving and Science Learnings

During the last few years several studies, philosophic in nature, have been undertaken with respect to the process of problem-solving and its relationship to science education. Efforts have been made to identify the techniques by which individuals respond to life situations, and if possible, to find out how science instruction may be used to help persons develop more effective abilities in making such responses. These studies tend to show that "the scientific method" and the psychological concept of perception are analogous to one another. Thus the scientific methodology involves a dynamic process rather than the following of a series of "steps of the scientific method." Much still needs to be done in this field since the conclusions from these studies tend to be more like hypotheses than recommendations. These studies would indicate that the study of the dynamics and psychology of the perceptual process may be a desirable part of the training of the science educator.

The Laboratory as a Learning Device in Science

Several years ago a vast number of studies appeared that attempted to settle for all time the relative merits of the individual

laboratory and the lecture demonstration. About all these studies proved was that both systems have great merit, that merit depending on where, when and how used.

During recent years many studies, encouragingly enough, have attempted to take the next step, namely, discovering the most effective usage of laboratory time. These studies point out clearly that ability to manipulate apparatus is a rather useless objective since the student becomes engrossed with the apparatus rather than the results. Hence the simpler the experiment, the better.

Other studies point out clearly that experiments that illustrate a concept or experience with which the child is already familiar serve as little more than ways for passing time. These studies indicate that scientific abilities, attitudes and skills are best developed by experimentation focussed around a problem to be solved in an area in which the student does not know the answers. Thus investigative skills are developed by experiments that demand the student investigate for answers rather than verify an answer he already knows.

Several studies have been undertaken to develop experiments that use simple apparatus, take less time to finish than the usual, and deal with one concept rather than several. The surface has only been scratched however by these efforts.

Another study dealing with laboratory management, although limited in scope, casts some light perhaps on the deficiences indicated above. A number of science teachers seem to be ignorant of the function of the laboratory, and of the types of activities suitable for meeting the stated objectives. Many are not aware of laboratory exercises other than those found in their respective laboratory manuals.

Instructional Facilities for Science

The practicalities of a school population exploding in size and the needs for more science classes seem to have motivated a number of studies dealing with science facilities. Most of these studies deal with rooms in two areas, (1) biology-general science, and (2) chemistry-physics. Most of them have taken cognizance of the need for flexibility, that is, using rooms for all sciences, laboratory and lecture, and for extra-curricular purposes.

Unfortunately, none seems to have come up with the movable laboratory desk because of necessity (?) of fixed gas and water connections, nor with rooms designed chiefly for general-education sciences in which more than four-fifths of the students enroll. The emphasis is still on chemistry and physics which enroll only a small portion of the science students.

Another suggestion is that efforts at design may pay more atten-

tion to centralizing storage space to a much greater extent than is now done.

Evaluation of Science Instruction

Evaluation of science instruction, in so far as developing valid standardized tests is concerned, still leaves much to be desired. A survey of recent research fails to bring to light any studies in this area.

One group of studies however dealt with the New York State Regents Examinations, sometimes referred to as a "vestige of the days of classical education," Such studies have long been needed since these examinations, over a half-century old, have never been analyzed in any major research sense. These studies indicated that teachers tend to look upon the examinations somewhat favorably. Although the teachers made a number of suggestions for their improvement, they thought that the examinations should be retained and that the standards of science teaching in the State of New York would lower if they were abolished.

Apparently these state examinations are about a reliable and valid, and discriminate just as well as do "standardized" tests in science. Yet it is surprising to note that a number of persons who have protested most loudly are employed by test agencies as consultants for standardized science examinations that are no better.

In conclusion it might be said that much needs to be done in developing valid instruments for measuring the objectives of science teaching.

STUDIES IN TEACHERS TRAINING

The Backgrounds and Competencies of Science Teachers

Probably all the problems already discussed are founded fundamentally in the conclusions that may be drawn from the rest of this review. Within the last few years, many studies have endeavored to discover the background training of science teachers as compared with the positions they are expected to fill. The evidence thus obtained is most alarming, and apparently is not likely to change greatly in the future.

There are apparently as many science teachers trained inadequately as are trained adequately. A vast proportion of teachers have much science background in one field and little in the others, although most of them are expected to teach many areas of science. Teachers with little or no training in some areas of science are often assigned to classes in those areas. This is especially true of the field of physics.

The problem is intensified in so far as general-education science courses, such as general science, general biology, and general physical science, are concerned. Few colleges provide subject-matter courses or professional methods courses that enable teachers to teach general courses in the sciences, most of the college training being specialized.

Another study recently points to the fact that "well-trained" science teachers are gullible, victims of superstition, and holders of many science misconceptions—merely another support to the inadequacy of training.

Despite all these status studies (and no more are needed) the literature is bare of studies that make a systematic attack on the problem of improvement. Such is long overdue, but without doubt many more status studies will appear, which will only serve to multiply the evidence that is already established. In addition many more studies are needed to establish the type of training program that will help science teachers to think scientifically rather than merely to memorize scientific facts and recite scientific principles without understanding their ramifications.

The Supply of Science Teachers

Not only are science teachers poorly trained but they are too few in number. Some may suggest that we should "thank Heaven for small favors." At present our needs are about 7000 per year with a supply of about 5000. By 1970 the needs will be about 10,000 with no anticipated increase in supply. Without doubt many well-trained science students are siphoned off by industry, leaving the less well-trained and the small numbers. It is interesting to note that the American Association for the Advancement of Science is now attacking this problem.

Summary

It would be redundant of course to summarize a summary. Hence this summary will take the form of a few suggestions:

1. Research workers in science education should explore the literature before undertaking studies. Often they repeat studies whose conclusions are sufficiently definitive to warrant no further study of the problem.

2. Research workers in science education may well examine the aims of their studies. Many studies, even though all established rules of research were followed with meticulous care, could never have produced other than trivial information.

3. Research workers in science education should undertake more studies that provide solutions rather than merely point out more problems, many of which are already known.

THE SCIENCE TEACHER IN THE TOTAL SCHOOL PROGRAM

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Successful supervision and administration of our schools becomes a cooperative enterprise in which all personnel of the school work together in setting the situation for learning. This need for all to participate rules out isolated departments. It requires abilities other than subject matter mastery, from principal and teacher alike.

How a science teacher may fit in with this philosophy can be partially answered by first reviewing two fundamentals from Harold Spears' book, *Some Principals of Teaching*, namely:

"School organization and administration have but one justification—the education of children."[1]

and

"The curriculum represents the total life of the school."[2]

From a science teacher's point of view, it may be said that science teaching should be organized so that (1) many subject matter fields are covered (2) such things as children's attitudes, thinking methods, and citizenship ideals be among the non-material considerations of the total program.

Thus a science room cannot be left to the odor of chemicals, or suggest dusty museums, or worse still, represent the room where only the mysterious dwells. In other words, science can become a pigeonholed department.

An administrator must understand the part science plays in everyday life of the child. He must understand basic concepts in the total science program. With the science teacher there is a need to realize that understandings in science may help a retarded reader, or add concreteness to arithmetic, enhance an appreciation of literature, and help boys and girls become better citizens.

At times the science teacher may be asked to participate in or prepare for a school program. Unless the principal gives reasons for the request, there is a chance that the teacher will fail to realize his part in the total school educational plan.

The science room is in a position to function in school assemblies, not only with technical helps, but as a source of entertainment. Teachers in auditorium, literature, social studies, art, music, and science all function cooperatively to produce programs, exhibits, fairs, etc., about citizenship, conservation, industry, and other interesting themes.

[1] Spears, Harold, *Some Principles of Teaching*, Prentice-Hall, Inc. 1949, p. 97.
[2] P. 119, *op. cit.*

Beginning with the simple task of writing on the board, there may arise the need for the science teacher to use the manuscript style of writing if children in the lower grades know only that method. He cannot substitute printing, he should know manuscript letters. In addition a science teacher should have an idea of his classes' vocabulary. He cannot dismiss this responsibility by overwhelming children with words. Perhaps talks with their homeroom teachers will help him judge where they are in vocabulary and reading. Frequently seemingly simple arithmetical problems arise in science teaching. But the science teacher cannot expect children to use fractions in the third grade if they are not taught fractions until the fifth. He may however greatly expand a fifth grader's understanding of fractions by preparing animal cages, weighing objects, and studying the heavens in the science room.

Perhaps many science teachers view their subject field much the same way people thought of the earth before and during the time of Copernicus. In other words the other departments seem to revolve about that of science. Yes, science can serve as the core, but so may social studies. It is difficult to have science teaching functional, unless the teacher visits the homeroom, the art classes, the shop, music room, and any other subject areas of the curriculum. College training may introduce one to the curriculum, but one must work in it to function.

Not to be ignored in the total curriculum of the child is his philosophy of life—the attitudes which will affect his responses to people and things about him. Once again the total school program must be understood. Little children have an outlook on life, but being immature they are plastic. The science teacher is in a position to use scientific methods. He may use the shop and his room to develop hobbies, thereby strengthening mental health. A literature teacher appreciates the asthetic attitudes developed with good teaching about conservation.

The scientific method of thinking and of working is a basic foundation in the science room. Without detailing this, the idea of expressing doubt, of withholding judgment, of acting upon scientific facts would generally appear to be noteworthy characteristics of a useful citizen in our democracy. One may ask whether a child's spiritual life is ignored by the science teacher. But first, is it ignored by the school program? The modern school has been taking over some functions which were formerly that of the home and church. The science teacher must realize this trend. He must know if his school program is cognizant of this part of a child's life. Is there a way to teach children to express doubt, yet have faith? Even though religion is not mentioned in the classroom, attitudes learned there can carry over to a child's religious training.

In summary it may be said that this approach is one of reviewing an over-all look at science teaching. It is up to administrative organization to see to it that teachers visit and understand one another's fields. And the teacher in order to cooperate, must be humble and realize that to understand the total curriculum of the child will take time and study, as much as was needed in his own subject matter field.

MATHEMATICS CONFERENCE AT LOS ANGELES

Advance plans for the Fifth Annual Conference for Teachers of Mathematics and a Fourth Annual Mathematics Laboratory on the Los Angeles campus of the University of California have been announced by University Extension, with conference dates set for July 5 to 15.

University Extension will present the sessions in cooperation with the Departments of Mathematics and Education at U.C.L.A., the California Mathematics Council, and the National Council of Teachers of Mathematics.

Principal speakers during the two weeks of activities will include L. J. Adams, Head of the Department of Mathematics, Santa Monica City College; Ida May Bernhard, Consultant in Secondary Education, Texas Education Agency, Austin, Texas; Frances Ceccarini, Burbank, City Schools, Burbank, California; Wilbur Dutton, Associate Professor of Education, U.C.L.A.; L. Clark Lay, Pasadena City College; H. Vernon Price, Professor of Mathematics, State University of Iowa, Iowa City, Iowa, and Clifford Bell, Professor of Mathematics and Head of Mathematics Extension at U.C.L.A. who is director of the Conference.

The Laboratory will meet daily during morning hours and the Conference during afternoon hours. Both are open to all teachers or prospective teachers of at least Senior standing. Fees set are $20 for each laboratory, or $30 for two study groups, or $40 for one laboratory and one or more study groups. General sessions will be open to any enrollee, irrespective of the fee paid.

Purpose of the Los Angeles conference is to bring together teachers interested in mathematics—arithmetic through calculus—to study common problems in the teaching of mathematics and to learn new uses of mathematics in various fields of endeavor. Additional information is available on request to University of California Extension, Los Angeles 24.

ELECTRONICS KIT

A Basic Electronics Kit—the first of its kind on the market—has just been introduced by Crow Electri-Craft Corp. With this low-cost kit, known as Model 50-A, electronics can now be taught by "visual experiment"—the same method that has made Crow Electric-Kits so effective in teaching the allied subject of electricity.

Model 50-A is designed for use in school shop courses, industrial training programs, armed forces training schools and similar education programs. It permits students who have completed the Beginners' Electricity course with Crow Electri-Kit Model 41-B to advance immediately into the study of Electronics. The kit contains 82 precision components—everything needed to perform 60 experiments in electronic fundamentals. There is nothing else to buy.

A four-page folder describing Model 50-A can be obtained by writing Crow Electri-Craft Corp. (division of Universal Scientific Co., Inc.), 1102 Shelby Street, Vincennes, Indiana.

THOUGHTS ABOUT THE TEACHING OF GENERAL SCIENCE

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A more appropriate title for this discussion should perhaps be "Random Thoughts about the Teaching of General Science." As one cogitates the various facets and implications of our present-day living and the educational problems which are interlaced with it, he almost starts to think in random fashion. One moment he reads about the big problem of increased numbers of students coming into our school system, but in the adjoining column of the paper it is reported that school bonds have been voted against or that a legislative body is not favorable to increased appropriations for the school system. Then one reads, first, about the need of technically trained people to maintain our superiority in world leadership, and, second, that the Armed Forces is in need of young men to carry on defense activities and consequently has called a group of young men from training in college into the military forces. Next he reads an article elaborating on what a wonderful job the school systems are doing followed by a statement from someone in the industries or the government that the young people who have completed their educations are not properly equipped to handle everyday arithmetic, simple everyday communications and the like. As I conjecture on this problem of teaching of science and of general science in particular, I sometimes find myself thinking in merry-go-round fashion.

Suppose that first I postulate my point of view on one or two general philosophies. As the head of a basic science department in a state-supported institution, I desire to express the philosophy of such a department. It is the function of a Department of Chemistry in a state-supported school to carry on five functions:

(1) To inculcate within the minds of young men and women a better and higher concept of citizenry;

(2) To teach the fundamentals of chemistry to students planning on engineering, home economics, medicine, medical technology, etc., so that they will have an appreciation of how the science of chemistry pertains to their professions and to their everyday lives;

(3) To teach the fundamentals of chemistry to those undergraduate students who have chosen to enter the profession of chemistry as their life's vocation:

(4) To provide graduate training in chemistry and to develop the future leaders for the state and the nation in the field of chemistry;

(5) To increase and to make important contributions to our knowledge of and to disseminate information about the science of chemistry.

Briefly, therefore, a Department of Chemistry is both a service and a professional department. It functions to provide essential training in chemistry for those persons desiring a liberal education or a background for the allied professional fields such as engineering, agriculture, etc. It should participate in carefully planned programs of adult education so that those who desire to continue learning about the world in which they live may continue to do so. It should assist, if possible, boards of education and other properly constituted bodies in the development of the most useful science programs at the secondary school level. As a professional department it provides the background and the inspiration to stimulate capable young people to become leaders in their chosen field of endeavor.

Obviously then, it should be easy to follow why a chemistry department head should be interested in the teaching of general science. A department of chemistry takes a product from one part of the educational system and works with that product to further develop it so that it can participate in this complex society of our times. The department should also for two reasons be very much interested in the preparation of potential science teachers. First, members of the department have young people going through the educational system, and second, we should give the very best preparation possible to those who are entering the teaching profession. I shall grant that in thinking about the problem I may have developed some prejudices but at the same time I probably have attained a more open-minded point of view on other points.

I sincerely believe that the entering college student of today has more knowledge than those of 30, 40 or 50 hears ago. I also think that the high school graduate of today who does not go on to college is far better equipped to face the problems of his world than his counterpart of the preceding two generations. I think further that today's high school graduates are far better acquainted with the applications, implications and ramifications of science than those of 25 years ago.

It is my belief that many of the young people who go into medicine, engineering, the sciences, into business, art, etc., make an important decision, unconsciously, when they are passing through the late elementary, junior and senior high grades. This important decision is the determination of a future vocation. Accordingly, the teachers in these grades bear a great responsibility—they, too, are unconsciously assisting in the decision-making. Is it any wonder then that those of us who are responsible for a later educational stage in the

development of a young man or woman should be interested in the science teaching in the lower levels? We are desirous that anyone who is proceeding toward the field of science shall get the bast background in his early training. We are desirous, too, that those who have the capabilities shall not be discouraged so that they will take up an area not to their liking as a final choice. Our security as a nation and as individuals depends upon the best persons with special training being available to provide us with the necessary technical information when needed.

Interest in science instruction at the lower levels is two-fold. First, it concerns the type of instruction which is greatly dependent upon the quality of the teacher. Second, it concerns the type of subject matter. Is it superficial or does it have depth? Is it narrow or broad in concept?

Let us think about the first point. Will the oncoming generation of science teachers be satisfactory from the quality point of view? I am fearful of this point. Planning programs for prospective teachers have undergone a quiet revolution during these last few years. No one person, no one group is responsible for it. We have noticed the movement to extend programs of general education; and with the growth of these programs substantial reductions in subject matter areas were forced. Less time has been available to develop good combinations of teaching majors and minors. For example, in one of the more educationally minded states of the mid-west area a potential high school teacher can get a teaching minor for the social sciences with only freshman and sophomore courses in the area. In another instance a physical science minor can be achieved by combining the general science course in general education with a part of a freshman year program in chemistry and the first year of college physics. This individual's program can be weak not only in the physical sciences but in the biological sciences as well. Yet, he is supposed to be the general science teacher of the next generation. Is he going to be the type of individual who should be involved in helping a young boy or girl make the important decision about his future life's work? Unfortunately, the chances are also good that this same individual will have but an average to poor college record. The students with better records will have selected other goals then elementary or secondary school teaching for their vocations.

In addition to the impingement of general education programs on the college curricula there is a creeping increase in the required professional education courses in the programs of prospective teachers. This creeping increase added to the general education courses means but one thing. Solid training in subject matter has to be eliminated. The result is a more superficially trained teacher. Having made this

particular statement I must add two other comments. First, I do not want it construed that I am against professional education courses because I am not. I am opposed to too many of them and particularly to those that are too theoretical or philosophical in character. I think that all prospective college teachers as well as teachers in the elementary and secondary areas could profit by the appropriate professional education courses. One of them should be in the development of the American college and university system and one should be in classroom supervision. Second, it is unfortunate that the superficially but supposedly more broadly trained teacher is looked upon more favorably for employment by many superintendents and principals. I grant the argument that a great majority of our high schools are those of smaller enrollment and must employ teachers who are versed in two or more subject fields. I do not agree, however, that these teachers should be poorly trained. This next thought perhaps should not be put down in black and white, but it appears to me that only too frequently a superintendent or a principal does not seem inclined to hire a new teacher, fresh out of college, who has an outstanding college record. One cannot but help gain the impression that the school officials are not desirous of bringing anyone into the school system who would do some things better than they can.

We must not forget that we are in a period of change and that calm thinking should be the order of the times. We are passing from an era of low manpower to an increasing one. The problem of getting properly trained personnel for teaching and for industry and for the Armed Forces during these last few years of a low numbered manpower potential has seen recruiting employed which has utilized all types of techniques, some good and some bad. As in the past, however, there is still need for well-qualified capable people in science and engineering and other specialized fields, but as we move into this period of greater manpower potential, let us emphasize the quality and not the quantity aspect of the problem.

Without stressing statistics let us quickly review one or two factors. We are all aware of the oncoming wave of boys and girls in the classrooms of the nation, but the wave of preparation to take care of them is lagging. In the universities, colleges and junior colleges of the country there are about 61,300 teachers of aeronautics, atomic energy, engineering, naval science, the physical and the biological sciences. Of the approximately 17,500 instructors in the physical sciences, 6,400 are in chemistry and 4,500 in physics. Note, in connection with these figures, that but 2% of those in the engineering profession are engaged in teaching; 25% of the physicists are in teaching. Naturally we can ask the question whether the teaching pro-

fession can maintain its relative stability in these various areas in view of the demands by more affluent employers.

In connection with the critical teacher shortage the engineering and scientific manpower commissions have taken the shortage so seriously that they have a joint committee working on the problem. Scientists and engineers are naturally concerned about the quality of mathematical and scientific instruction that boys and girls receive during their formative years. There has been a decline of 53% since 1950 in the number of teachers trained and certified to teach science or mathematics. This is little short of a crisis that threatens the future of the scientific and engineering professions. In many instances instruction must be entrusted to teachers untrained in mathematics or science and the resulting loss is two-fold. Pupils who are qualified to enter these professions get neither the inspiration nor the guidance to do so, and those already interested fail to get the basic training that is a prerequisite for good college work.

The above mentioned commissions are not unmindful of the fact that the shortage also affects other fields of instruction. Francis Keppel of Harvard University has dramatized the situation in the following statement:

> "If we assume that teachers should be college graduates, that the proper average number of students per teacher should be around 30; if we use the latest population estimates; if we assume the normal turnover in the profession; and if we assume that all four-year colleges will turn out about the same number of graduates a decade hence, then half of all college graduates or more will be needed for teaching. Obviously, this is fantastic; yet it gives a measure of our predicament."

Although the Engineering Manpower Commission and the Scientific Manpower Commission and other scientific and technological associations are actively pursuing programs to secure science manpower their efforts are jeopardized by the kind of science and mathematic course offerings in secondary schools. The faculty of the Department of Science Teaching at Teacher's College, Columbia University, reports that an ever increasing number of small high schools across the country has wholly abandoned courses in physics and chemistry and many high schools now offer mathematics only in the ninth grade. Even in those high schools where physical science and mathematics are offered the enrollment of students in these elective courses continues to decline.

We shall look at this problem briefly and without detailed statistics as the physics problem appears in the secondary schools of the present time. In an article in the *Science Counselor* for September, 1954, W. C. Kelly, of the Department of Physics, University of Pittsburgh, points out that:

"When we consider the status of physics in the secondary schools of this country we confront a paradox. The importance of physics in our national life increases daily but the interest of high school pupils in the subject as judged by enrollment drops toward the vanishing point. Physics has completely changed our pattern of military defense, created whole new industries, explored nebulae and probed nuclei and has worked a fundamental change in our thinking about the great world and the small. Yet in 1948, a representative year, less than 6% of our high school pupils were engaged in the study of this truly basic science."

Statistics taken from data compiled by the National Education Association illustrate the trend in physics enrollment:

PERCENTAGE NATIONAL ENROLLMENT IN PHYSICS

1895	22.8%	1922	8.9%
1900	19.0	1928	6.8
1905	15.7	1934	6.3
1910	14.6	1948	5.8
1915	14.2		

It can be seen from the above data that the percentage of national enrollment in physics has been constantly decreasing. The best that we can say is that it is stationary at a low level. Actually, over 75% of our high school population has no contact with physics and school boards and high school administrators find themselves neither willing nor able to continue elective courses in which few students show interest.

Although our primary interest in this discussion is on general science, we can use physics as a specific illustration. This subject, as can general science, can contribute much to the education of any pupil, whatever his future vocation. He needs not only an understanding of our physical environment, he must know how to control it. In a technological world practically everyone requires some knowledge of machines, and physics is immensely helpful to those who will study for the engineering and scientific professions.

Dr. Kelly in his article about physics points out some reasons why it has been hard to arouse student interest in the subject and what he thinks can be done about. What he has written about physics can be said of any one of the other sciences and of general science in particular.

(1) Most people do not know what physics is about. We need pamphlets, movies, and popular lectures to explain physics to the public.

(2) Physics is regarded as impossibly difficult. We must convince our pupils that anyone of moderate ability, who has studied algebra and plane geometry, can master a high school course in physics.

(3) We should form "fast" and "slow" classes wherever possible, to serve both average and gifted pupils.

(4) The supply of well-trained teachers of physics is far short of our needs. The influence of the teacher on the attitude of the pupil toward physics is usually decisive.

(5) Thorough revision of high school physics courses is needed, in the direction of more intensive content.

(6) Demonstration experiments and student laboratory work, though expensive and time-consuming, are essential if class interest is to be kept at a high level, and they should be restored to introductory physics courses.

In concluding our remarks about the decline in physics and other science enrollments let us emphasize that when young people who might ordinarily be attracted to science careers and who plan to go on to college come to their higher education inadequately prepared for a program in the sciences, they are easily diverted to the liberal arts and other areas. This is occurring coincident to unprecedentedly heavy enrollments for the next decade in secondary school and colleges. Thus, the lack of science teachers and out-of-date science programs constitute a wastage of science manpower potential rather than a shortening of potential power.

In concluding this first part of our discussion on the various ramifications of teaching general science, let us ask a few questions. We will not attempt to answer them at this time; the future may give us the answer. Are the teachers now being prepared obtaining an adequate and sufficient background for science teaching? Are they looking at teaching as a job to earn a livelihood or as a challenge to develop young people? Are they trying to stimulate young people with the proper capabilities to follow science or some allied field as a vocation? Are they interested in teaching the young people under their direction not only how to think but also how to do things? Are they creating an awareness of the importance of science in everyday life for their students? Are they using homely illustrations to show where natural laws are affecting our day by day living?

We shall next consider a question which is frequently subject to debate. Shall there be laboratory work in connection with a science course? This, too, is a question with many angles. For example, it implies that the teacher is capable of teaching others to do things with their hands. It implies that the teacher has been provided with the facilities with which to teach pupils how to use their hands. It further suggests that there is available time for the project. One might ask then why am I interested in whether or not an individual can use his hands. On the one hand, we must admit that the dentist, the artist, the doctor lives by his hands. When he loses the touch

he no longer is a capable dentist, artist or doctor. But some of you will say that these are professional people who have been listed. Let us be broad-minded. The plumber, the electrician, the service station attendant also live by their hands. They, too, once they lose the capacity for properly using their hands may no longer make a living by that particular means. One place where an individual may learn some facility with his hands is in the laboratory classes in his school program.

On the other hand, those of us who must work with the product coming from the lower echelons of our educational system are concerned with the decreased lack of facility in the use of tools and of improvising with ordinary materials to get a job done. Perhaps some of us are thinking nostalgically of the old model T days when every boy knew how to repair the old car with baling wire and a pair of pliers. Of course, with the modern car unless one has all the fancy special tools he can hardly do a thing other than having the service station attendant keep it serviced. Seriously we have noticed an increased lack of capability on the part of our students to be able to work on equipment, to be able to make simple repairs, to build simple electrical circuits. In one department of chemistry in the Big 10 every graduate student is required to take a course in techniques. Other departments are thinking about similar programs. Obviously the reason for these courses is to correct weaknesses in earlier training.

Thus far we have looked at the course in general science as part of the training of a young person in the use of his hands. However, we must also look at the laboratory program in a much broader sense. All of us realize the increasing pressure by administrators to eliminate laboratory work. One of the places wherein a budget may be trimmed is to delete laboratory supplies and equipment. These materials are tangibles that can be thrown out. It is more difficult, however, to eliminate intangible expenses. At the moment, however, we are thinking about the tangible aspects of the problem. We shall extend the concept of a young person being trained in the use of his hands to the fact that laboratory work is also a phase of audio-visual aid. It is interesting that some persons who decry putting money into laboratory supplies are the very first to argue for slide and movie projectors, for fancy diagrams, for models, etc. Experiments with objects is a part of audio-visual aids. It may be that familiarity with laboratory teaching has caused contempt of it.

I shall now paraphrase the thoughts of Dean Raymond E. Kirk, of Brooklyn Polytechnic Institute, on why scientists favor laboratory work as part of a teaching program.

First, scientists believe that laboratory experimentation is the

best known method for inducing young persons to use their minds. How can a young person be interested in chemical change if he has never carried out a simple chemical experiment such as reacting baking soda and vinegar. A general science teacher can correlate the leavening process in baking with the gas evolution resulting from the baking soda-vinegar experiment. How can a young person become intrigued with plant growth if he has never had the opportunity to do some simple experiments of the "green thumb type." The general science teacher has a golden opportunity to show young people how to start new plants, either from seeds or slips and to interrelate these facts with the nursery business, with the continued existence of forest areas, with the large agricultural businesses of the world.

Second, we believe that is in the laboratory that orderly habits can be established. To observe and to record what is seen, to measure and to report in tabular form the results of measurement, to relate and state concisely conclusions to summarize and to state clearly the summary; all of these are good habits to make young people better members of this world of ours. These habits are of great value far beyond the fields of science.

Two side comments should be added at this point. During World War II it was my experience to teach concurrently from an authorized outline two groups of military men. Both groups were of college age. For one group, laboratory work was part of the schedule, for the other it was deleted. On the basis of ability, each of the two groups was about as equal as it is possible to make selections. Those of us who handled these classes had no doubt at the end of one term that those who performed the laboratory experiments were better rounded out than those who did not work in the laboratory. Also, in the second term when both of these same groups had laboratory assignments, we observed that the group which had not had laboratory work was definitely handicapped compared to the other group. The term "standard solutions" meant much more to those young men who had made titrations than it did for those who had only discussed the significance of the term.

The other slight comment applies to writing. The late Miss Harberger, who taught English courses for engineers at Ohio State University for many years, frequently stated that she could observe in the writing habits of her students an increased organization and clarity as the students began to get into the laboratory phases of general chemistry. The constant requesting in the laboratory teaching of what do you observe and how do you express it clearly carried over to the writing of themes. Writing and science are not detached subjects. However, let us get back to the main topic of the place of the laboratory in teaching.

Third, we scientists believe that the laboratory is one place were the historical development of science can be taught well. Here it can be shown that qualitative experiments develop into quantitative ones; how general observations lead to preliminary generalizations; how the laws and theories of science have their origin. It is unfortunate that in this world which is thriving on the results of science that so few people have any idea of how science grows and that many obtain false ideas. Recently in some talks to non-scientific groups I have attempted to show how the chemist goes about proving the composition and structure of simpler compounds of value in medicine. One cannot teach much chemistry in such a demonstration but one can express a tiny portion of the philosophy of science. The general science teacher in his laboratory teaching has a marvelous opportunity to do some general and liberalizing education and particularly about the implications of science.

Fourth, we believe that it is in the laboratory that the scientists of tomorrow will be recruited. The concept of science is a growing, changing, dynamic concept; it is the growing, changing, dynamic fields that attract keen young minds. However, let us not misinterpret the term recruiting as we have used it in the above statement. We are not implying that the science teacher should attempt to convert young people from other fields into science. Heaven forbid that idea. We are implying that the science teacher should encourage the capable and gifted young man or woman with an aptitude for science or its related fields to pursue further learning in those fields. We have already stated that we are fearful for the future because of the possible poorer quality of the oncoming generation of potential science teachers.

Before we leave this phase of our discussion let us make one more comment on laboratory teaching. Most arguments favoring abandonment of laboratory claim that the objectives claimed for laboratory instruction have not been accomplished. I quote Dean Kirk.

> "All of us who teach science will admit that we have fallen far short of our stated goals. Blame us but do not blame the method! Help us to do better, help us to train others to do better still, but do not doom our young people to sterile instruction."

We have mentioned that laboratory instruction is a phase of audio-visual aids instruction. We shouldn't forget that a good lecture demonstration is also an excellent visual aids procedure. Many thoughts can be transferred by means of a good demonstration. Let us review the gas laws for a moment. We recall quickly that it can be demonstrated that gaseous substances change volume to a relatively great extent with temperature change and that volume changes result from pressure changes, but how frequently do we demonstrate in our

general science programs that the gas laws are involved in the operation of the gas meter in our homes. The functioning of the gas meter was formerly a pet lecture demonstration for the general science teacher—now, the oncoming science teachers do not know how the gas meter works.

Equipment for a laboratory or lecture experimentation program need not be expensive. Cheap, simple items are frequently more efficacious as teaching tools than more complex equipment. One can demonstrate acid-base conversions with a little grape juice or with litmus just as easily and more colorfully than he can with a $400 pH meter which may not be working when you want it to show off. Corks, files, a simple protractor, a yardstick, all of these can be used to demonstrate vectorial relations. All of these are inexpensive, readily available. Baking soda is still sodium carbonate. Table salt is sodium chloride.

There is a failure of accomplishment in the field of lecture demonstration which is also due to the scientists in the colleges and universities who are preparing our present generation of general science teachers. The present-day instructors are far more interested in writing on the blackboard and in talking than they are in making one good point by a good demonstration. One must grant also that lecture demonstrations can be overdone.

Another random thought comes to mind at this moment. LeChatelier's principle is always at work. It applies to the field of teaching as well as to the field of science. In rough approximation we recall it as implying that when a stress or strain is put on a system the system reacts to relieve the strain or stress. So it is with science teaching. Of recent times industrial companies have been very active in propagandizing phases of teaching. The General Electric Company has put out some splendid articles entitled, "Why Study Mathematics," "Why Study English," and "Why Read"; another company has put out an advertisement on how to build a simple motor. Still another in a series of advertisements outlines simple experiments with home equipment using water treating agents. Why are these companies or agencies putting out such information? There are many reasons, but one is dependent on their observations of the young people who are their new employees. The weaknesses noted in the new employees are stressed in the idea of the advertisement or the published article. Those who are preparing these statements are educationally minded; they have youngsters in school; they note the weaknesses in the preparation of their new employees; they want to prevent an extension of this type of preparation. Their actions are a subtle way of suggesting to science teachers and to administrators where there are weaknesses. Their suggestions are an attempt to relieve the stress

put on our educational system. LeChatelier's principle applies to teaching and to life as well as it does to science.

In the discussion thus far we haven't settled any major questions, but we have brought forth quite a number of thoughts that we should consider for the future. If we wanted to, we could continue thinking in this random merry-go-round fashion. We shall conclude by simply stating that life is a curious concatenation of categorical coincidences. Let us work to eliminate the weaknesses in our teaching, let us strive to improve the strong points. Our task for the future is to do the very best that we can for the young man and the young woman entrusted to our care in our school rooms.

SECOND ORDER INTERPOLATION

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Numbers in a table are arranged so that we can call those in the margin a_0, a_0+1, a_0+2, etc., and the corresponding functions f_0, f_1, f_2, etc. When we interpolate we wish to find how much to add to f_0 to get the value of the function that corresponds to a_0+x, where $x<1$.

If we plot the points $P_0=(a_0, f_0)$, $P_1=(a_0+1, f_1)$, $P_2=(a_0+2, f_2)$, two interesting cases arise: either P_0, P_1, P_2, lie on a straight line, or they do not. In the first case we have the equal slopes

$$\frac{f_1-f_0}{(a_0+1)-a_0}=\frac{f_2-f_1}{(a_0+2)-(a_0+1)}$$

which shows that the two tabular differences, $T_1=f_1-f_0$, and $T_2=f_2-f_1$, are equal.

Let us examine the rule by which we ordinarily do interpolation. It may be written

$$y=f_0+x\cdot T_1$$

where x is the fraction (usually expressed in tenths), of the interval we wish to add to a_0, and T_1 is the tabular difference for the interval. Graphically, this is the equation of a straight line: it gives P_0 when $x=0$, and P_1 when $x=1$, since $f_1=f_0+T_1$. This line will also go through P_2 for $x=2$ provided $f_2=f_0+2T_1$. But we know that $f_2=f_1+T_2=(f_0+T_1)+T_2$, so this is the same as saying: provided $2T_1=T_1+T_2$, or: provided $T_1=T_2$.

But in the other case, where $T_1\neq T_2$, their difference, $S=T_2-T_1$, must be taken into account somehow. Let us see how much of this

"second difference", $M \cdot S$, we can add to the formula. Take

$$f_0+x\cdot T_1+M\cdot S$$

so that it will give P_2 correctly as well as P_1 and P_0. For P_0 and P_1 we do not want any S added, so M must contain the factors x and $(x-1)$ to nullify S when $x=0$ and $x=1$. This gives

$$f_0+x\cdot T_1+m\cdot x(x-1)S.$$

To give the correct value of $f_2=f_1+T_2=(f_0+T_1)+(T_1+S)=f_0+2T_1+S$ when $x=2$, we equate to $f_0+2T_2+m\cdot 2(2-1)S$ and get $m=\frac{1}{2}$. So the formula to use when successive tabular differences differ is

$$y=f_0+x\cdot T_1+\frac{x(x-1)}{2}S.$$

One further fact must be noted. Since interpolation is carried out as if all decimal points in the table were removed, we round off any correction less than one-half. The S term in the above formula may be written, since $x(x-1)=(x^2-x+\frac{1}{4})-\frac{1}{4}$, as

$$-\left[\frac{S}{8}-\frac{S}{2}(x-1/2)^2\right].$$

The number in the brackets is therefore always less than $S/8$, and so if $S<4$, this term gives less than one-half, and may be ignored.

In other words, if successive tabular differences differ by less than 4, ordinary interpolation may be used.

If the second successive second differences are not alike, another term containing the factors x, $(x-1)$ and $(x-2)$ may be added, but it can be shown that this term will not affect the interpolated result if the third difference is less than 8.

THE WHITEHOUSE COMMITTEE ON EDUCATION

The Committee at its first meeting recognized there are a host of problems which schools must face in the states and territories. It decided the problems, in general, could be grouped as follows:

(1) What should our schools accomplish?
(2) How can we get the school facilities needed?
(3) How can we get enough good teachers—and keep them?
(4) How can we organize our schools most efficiently and economically?
(5) How can we pay for our schools?
(6) How can we obtain a continuing public support of education?

The Committee also decided that carefully organized discussions of these six problems, attempting to answer for each the questions—"Where are We? How did we get here? Where do we want to go? How do we get there?"—should serve as an important step toward meeting the responsibility placed on the conference program by the President.

TRENDS IN HIGH SCHOOL MATHEMATICS

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Identification of trends in mathematics is always hazardous. Unforeseen circumstances may check a trend or change its direction. Wars, depressions, changing political and educational philosophies—all have important influence on the amount and kind of mathematics taught in the schools. Ever-increasing birth rates, seriously overcrowded classrooms, and inadequately prepared teachers—these, also, make difficult both the identification of current trends and the prediction of future developments.

Nevertheless, identification of trends is important for we do like to know where we are going. This paper describes some of these apparent trends and offers a few opinions, reflections, and predictions.

The first trend is concerned not so much with the subject matter or results of mathematics as with its methods of proof. Mathematics is an abstract deductive science, a fact never made clear to most high school students. How many ever do learn "what mathematics is really all about?" How many ever do discover that mathematics is essentially a chain of propositions each proved in terms of those which precede, with every new word defined in terms of those which have gone before? How many ever do see that not all words can be so defined, that some must be left undefined, and that not all statements can be so proved, that some must be accepted without proof? Few indeed understand Bertrand Russell's definition: "Mathematics is the science in which we do not know what we are talking about nor whether what we are saying is true."

Agitation to bring into sharper focus the nature of mathematical thought is not a new development but recently it has increased in strength and changed in emphasis.

In the past, geometry was the one subject which was supposed to give insight into the nature of mathematical thought. Unfortunately in a majority of instances it was not "properly taught"; students merely memorized the mathematical proofs and repeated them back to the teacher. Even when emphasis was shifted from memorization of book propositions to proving of original exercises, a majority of students failed to learn the nature of mathematical proof.

Approximately fifteen years ago some educators took a new approach. Still interested in showing mathematics as a beautiful chain of logically connected propositions (a sort of frozen harmony) they nevertheless felt that geometry had to do more than teach an under-

standing of mathematical thought. It had to teach a way of thinking which would be applied, not only in geometry, but in life itself. They were convinced that the only way to insure this transfer was to include appropriate non-geometric materials in the geometry course.

The original experimenters (Fawcett, Ulmer, etc.) made extensive use of non-geometric materials, taught specifically for transfer to life situations, and evidently had considerable success. But their method filtered down rather slowly into the average geometry classroom, and, as it did so, there was a change in emphasis. Instead of employing non-geometric materials to effect transfer to life situations, teachers are now using these materials primarily for two other purposes: first, to motivate the study of geometry, and second, to supply familiar illustrations with which to explain the geometric concepts. Most schools do not demand demonstration of the ability to use clear thinking in non-geometric situations but instead are satisfied if formal geometry teaches students what is meant by mathematical proof.

But now when a college mathematics teacher says (3, p. 306) "I would much rather have a freshman student with experience in deductive thinking but without the memory of a single theorem of geometry, than one who knew ten thousand theorems but had no idea of the nature or importance of reasoning," the subject of demonstrative geometry itself goes on trial. If there is an easier way to learn what mathematics is all about than struggling through a course in demonstrative geometry, the case for geometry is on shaky ground. If it is deductive proof that is important while the geometric theorems have small worth, could this objective be achieved more quickly, more efficiently, more easily, in some other area of mathematics instruction? Perhaps algebra could be used to teach the nature of mathematical thought. Certainly, as May points out (3, p. 306), many of the proofs of algebra are easier than the traditional demonstrations of Euclidean geometry. Of course, geometry does have one advantage; it has figures which illustrate the things that are said and done.

Where the present trend will lead is not yet clear. Traditional geometry may continue to hold a central position but there are indications that some reorganization of high school mathematics is not far distant. Rudolph Langer says (2):

> "The tempo of life has become furious. . . . To remain static in such times of stress means just one thing, namely, to be left behind. We should be smug indeed if we were to think that mathematics and the teaching of mathematics could be excepted from these generalities. And if we grant that, it is certainly only the part of ordinary wisdom to take stock of ourselves and our practices."

Many of the traditional topics in high school mathematics do not achieve practical ends nor do they give insight into the nature of

mathematical proof. Sweep away these topics, we are told, and replace them with modern concepts such as introduction to set theory or statistical inference or symbolic logic, all of which have elementary and practical aspects but which give insight into the nature of mathematics.

Plans for reorganization have been accelerated by the present critical shortage of scientists and engineers. Crown-Zellerbach Foundation has awarded fellowships to thirty-two west coast high school teachers to study methods of tailoring instruction in mathematics to the needs of science and engineering students. These teachers will question scientists and engineers concerning the mathematical needs in their fields and will then try to translate the information into new high school courses. But whatever new subject matter is added, mathematicians are firm in demanding some attention to methods of proof. Ability to distinguish between "true" and "false," between supposition and proof, between informal proof and rigorous proof—these things, they say, should not be completely postponed till college years.

A second trend has been called "creative teaching." In some ways running counter to the demand for a more rigorous mathematics, the approach is psychological more than logical, inductive more than deductive. The classroom becomes a laboratory in which teacher and pupils investigate a problem at various levels of abstraction (object, picture, semi-symbolic, and symbolic). The students examine numerous particular cases, discover for themselves the required relationships, and make the necessary generalizations.

This technique is not new. Teachers have always tried to make plausible the concepts of mathematics but today emphasis has shifted from demonstration by teachers to exploration and discovery by pupils. To this end, multiple aids, especially developmental aids which the pupil himself can manipulate, are being utilized to an extent unknown in the past. Using these aids and employing experimental methods, each student can make discoveries and formulate general theorems in every field of high school mathematics. In geometry, for example, he can discover for himself that the medians of a triangle are concurrent, that the right bisector of any chord passes through the center of the circle, that the ratios of corresponding sides in similar triangles are equal. In like fashion, the fundamental ideas of algebra can be made plausible through use of concrete devices which "make sense" to the student.

This approach to the learning of mathematics is not favored by all persons. Eric Temple Bell (1, p. 260) has called laboratory exercises in cutting, weighing, and measuring "silly, incompetent, immaterial, and irrelevant," not really mathematics at all.

Nevertheless, the popularity of this method continues to grow. Teachers have found that completely logical explanations mystify their students but that informal investigations have meaning. They have discovered that experimentally-reached conclusions are understood whereas completely correct procedures of logical mathematics give no meaning whatsoever to the pupil's work. They leave him utterly cold.

How, then, can teachers reconcile these apparently conflicting trends? The answer: There is no real conflict; good mathematics teachers have always used the two procedures to reinforce each other. To illustrate: A geometry class establishes some property of a circle by cutting and measuring, solves numerical problems in the arithmetic of the circle, and finally justifies the informal results by means of a formal proof.

A third trend: Algebra is becoming a more useful course. What in fact could be more useful than a study of relationships, dependence, and functionality? Every aspect of our lives is affected by our relationships with the people and the things around us. Health is dependent on good food. Success is dependent on ability to get along with others. The right to assemble freely or to speak freely is a function of the form of government under which one lives. Admittedly this concept of functionality, the manner in which one variable depends on another, is important in life situations.

So also has it been considered a suitable unifying principle in the study of mathematics. As early as 1923 the National Committee on Mathematical Requirements sounded the call for teachers to reorganize their courses around the function concept. The ninth yearbook of the National Council followed up with a thorough exploration of the possibilities of unifying all elementary mathematics around this concept. But reforms come slowly. Twenty or thirty years usually elapse before new ideas can penetrate the average classroom, especially in a subject like algebra where teachers are tied so closely to textbook content. It takes time to write new textbooks but this has now been done. Consequently, teachers today are emphasizing, more and more, the relationships between variables, the dependence of one quantity on another, in short, the whole concept of functionality.

In so doing, they have elevated the formula to a central position in the introduction to the course, replacing abstract operations and the equation as the core of instruction in this subject. Relationships in formulas do dictate many of our life activities. An automobile ride brings encounter with $d=rt$. A trip to the bank gives contact with $i=prt$. A stop at the gas station requires understanding of $p=cn$. We employ the Pythagorean relationship to compute the distance from

home plate to second base. We use the constant ratio formula to estimate the true interest rate in installment buying. Persons studying radio must be able to cope with the formulas fundamental to electricity while all persons, regardless of special interests, should be able to use the formulas for perimeters, areas, and volumes. These examples, and many more which could be listed, show that thorough understanding of formulas is extremely useful in life outside the classroom walls.

Of course, people can get along without knowing any formulas. So also can they exist with little or no knowledge of geography or history or physical science. But a strong case can be made for algebra when emphasis is placed on the formula studied with particular attention to relationships, dependence and functionality. A student, who can quickly tell what happens to c in $c=2\pi r$ or to A in $A=\pi r^2$ when r is doubled or tripled, is learning to think in a manner which will prove useful in numerous quantitative situations found outside the classroom. Little wonder, then, that the formula has become the heart and the function concept the brain of beginning courses in elementary algebra.

A fourth trend is related to non-sequential mathematics. For the past twenty-five years teachers and administrators have worried about the kind of mathematics to teach those students who are not interested in traditional algebra and geometry or who are unable to cope with the abstract content of these courses. General mathematics has been prescribed for this group but there has not been close agreement on content. Many teachers and textbook writers have now made the authoritative Check List of the National Council their guide in the selection of content and have thereby provided for a sound basic program for all students.

Other schools have introduced courses in arithmetic. These often deteriorate into drill courses enrolling a heavy concentration of problem children. But the literature is replete with calls for a different kind of arithmetic, an arithmetic based on the thesis, "Number is a system; it should be taught as a system." Methods which have revolutionized arithmetic in elementary schools are beginning to penetrate the high school level where teachers are now placing less emphasis on drill, more on meaning. At the same time, writers in this field have suggested that excursions into the study of Roman, Mayan, binary, duodecimal and other systems will stimulate interest in and broaden understanding of our own decimal system. There is one difficulty. How can schools find enthusiastic and imaginative teachers who are both ready and willing to teach classes in arithmetic? No easy answer is at hand but fortunately colleges are now giving much thought to the solution of this problem.

In the more progressive schools, another type of course, consumer mathematics, is finding a place at the Grade XII level. Consumer mathematics includes taxes, insurance, budgeting, and the wise use of money; statistics is sometimes added since the intelligent reader is also a consumer of the mathematical ideas found in newspapers and magazines. Consumer mathematics is a useful and interesting course but not an easy one to teach. There are two reasons. First, teachers have to expend much energy merely trying to keep materials fresh and up-to-date. Second, they must devote such a large amount of time to the social phase that mathematical meanings may be neglected. To guard against this latter possibility, teachers must budget their time with unusual care. Failure to do so will force many students to use rote learning as the only avenue to success in the computational aspects of this course.

A final note on non-traditional courses. Teachers have heard so much concerning the need for social units that they may feel obligated to organize their teaching, at least in part, around life activities. If so, they can easily become more than a little frustrated for certainly the task is not easy. Fortunately some states have now developed excellent courses of study; Pennsylvania, in particular, has spelled out detailed activities to guide the person who is assigned to teach these functional mathematics courses.

A fifth trend is the lively interest in making mathematics palatable. Conferences and workshops on applications are being held; books on mathematical recreations and history of mathematics are being written; textbooks, increasingly, are devoting attention to historical notes and unusual puzzles and games; and teachers are ever on the search for ideas to make the subject more palatable. Typical comments:

"When I mentioned topology in my geometry class, they wanted to know more about it. What are the best references?"

"I am letting the bright students spend some time on the history of number but they are devouring it so fast I am running out of materials. Can you help me?"

"I want a good story problem to motivate the study of locus."

A sixth trend, which includes the above, is the new interest in provision for differentiated instruction. In the past, teachers have been forced to tailor instruction to meet the needs of the average pupil. Good students were bored, weak students baffled. Recently much thought has been given to the problems of the slow and the rapid learner and many teachers are now discovering how to provide for differentiated instruction through long unit assignments, supervised study, sub-grouping, and other techniques.

The trends described in this paper are all well-defined but, due to the slow spread of new ideas and new practices, predictions for the

future are difficult. A better system of communication is needed so that all teachers have a chance to profit from the experiences and experiments of those who are staking out new ground. If we can correct this deficiency, if we can establish better lines of communication, then we will have removed one of the important reasons for the slow development of new practices in mathematics education. Further, we will have made the identification and prediction of trends a much less hazardous undertaking than it is at the present time.

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UNITS, DEFINITIONS AND ACHIEVEMENT IN ELEMENTARY PHYSICS

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1. The Problem

The purpose of this paper is to describe an investigation on the relationship between a knowledge of definitions and units and general proficiency in elementary physics.

It has been the writer's observation that many students get "correct" numerical answers to problems by a trial-and-error process. Since terminology in physics is operational, principles and their applications cannot be meaningful to a student unless he has the definitions and units at his fingertips. During Semester I, 1954–55, an investigation was carried out in the Physics Department of Western Michigan College with the object of finding an answer to the following question: *Is there a significant realtionship between a knowledge of units and definitions in elementary college physics and achievement in the subject?* The terms "knowledge" and "achievement" were defined as raw scores on multiple-choice tests to be described later.

2. The Method

a. The course population and samples

There were 84 students originally enrolled in Physics 103*A*—Mechanics, Sound, and Heat. Section 1, taught by the department head had 50 students; and Section 2, taught by the writer had 30

students. There was one girl in each of the two groups. The typical student was a male sophomore in the pre-engineering curriculum, and taking analytic geometry or calculus concurrently with physics. By the end of the semester the two sections were reduced to 47 and 25 individuals respectively; complete data were available for 41 and 24, subjects, which constituted the final samples.

b. The instructional methods

Physics 103*A* at Western Michigan College is a "standard" first semester 5-credit course in engineering physics. There are four lecture-demonstrations, a two-hour laboratory, and a one-hour quiz-discussion per week. The textbook used during the current year is *College Physics* by C. E. Mendenhall, *et al.*, Third edition (Heath, 1950). A number of problems assigned in the text constitute the nucleus of the work in each of the four quiz groups. In addition to the recitation and laboratory work, the student's achievement was evaluated by five one-hour tests and a two-hour final examination.

c. The tests

All the tests were of the five-alternative, machine-scored type. The items, constructed by the two course instructors, were similar to those in the *Cooperative Physics Tests for College Students*. The 20 items of test 1 and the 16 items of test 2 covered the subject matter in the first fourteen chapters of the text. The sum of the raw scores on these two tests was taken as a measure of achievement in Mechanics. The 20 items of test 3 were designed to measure a knowledge of units and definitions contained in the above chapters. An item from test 1 and an item from test 3 are reproduced:

A man steps onto a large spring scale in an elevator. The scale reads 160 lbs. The elevator starts downward with an acceleration of 8 ft/sec^2. The reading of the scale with the man still on it will be: (1) 168, (2) 200, (3) 40, (4) 120, (5) 160.

Energy cannot be expressed in: (1) ergs, (2) dynes, (3) joules, (4) foot-poundals, (5) gram-centimeters.

The final examination was divided into two parts: Part 1 consisted of 30 items on principles, devices, measurements, concepts and problems in Mechanics, Sound and Heat; Part II had 20 items on units and definitions. The scoring formula for each test was $S=4R-W$, where S = score, R = number of correct responses, and W = number of wrong answers.

d. Statistical design

Since the study was considered to be of a preliminary nature, the statistical design was kept simple. Because the students signed up

for the two sections in accordance with various personal factors, one could not assume that the two groups were random samples from the same normal population. The F-ratio and the t-test were the appropriate statistics for ascertaining whether or not the two samples could be pooled. In either case, the degree of relationship between the two areas of achievement would be indicated by the magnitude of the zero order correlation coefficient.

TABLE 1. MEANS, VARIANCES, F-RATIOS AND t-VALUES FOR TWO SECTIONS OF ENGINEERING PHYSICS
Physics 103A, Semester I, Western Michigan College, 1954–55

Section	N	Tests 1 and 2—General Mechanics—Maximum score = 144				Test 3—Units and Definition in Mechanics—Maximum score = 80			
		Variance	F	Mean	t or ν*	Variance	F	Mean	t or ν*
1	41	338	2.67‡	33.4	.82	289	1.36	27.6	3.41††
2	24	901		44.1		212		41.5	
		Final Examination—Mechanics, Heat, Sound							
		Part I—General—Max. score = 120				Part II—Units and Definitions, Max. score = 80			
1	41	685	1.28	61.4	.39	205	1.91†	32.7	3.01††
2	24	878		64.2		390		45.2	

* Aspin-Welch test, when variances are not homogeneous.
‡ Significant at the 1% level.
† Significant at the 5% level.

3. ANALYSIS OF DATA

The variances, means, F-ratios and t-values for both sections are shown in Table 1. It was found that there were significant differences between the variances or means on three out of the four comparisons. Consequently it was concluded that the two sections were not to be considered as comparable. Other data taken from the college personnel records tended to substantiate the existence of an ability differential between the two groups.

Product moment correlations between the general proficiency tests and the units and definitions tests were computed for each section. The results are shown in Table 2.

The most meaningful correlations were those between the tests on general comprehension and those on units and definitions over the

same subject-matter. For the Mechanics tests the correlations were 0.56 and 0.71 for sections 1 and 2 respectively; for the final examination the values were 0.70 and 0.85. The four correlation coefficients were significantly different from zero at the one per cent level. Fisher's z was used to test the significance of the difference between the correlations for the two sections. The only significant difference was found for the correlations coefficients between the General Mechanics test and the Units-Definitions part of the final examination. The most reliable and meaningful correlations (0.70 and 0.85) are those between the two parts of the final examination: by the end of the semester, the students had become acquainted with the aims and

TABLE 2. ZERO ORDER CORRELATION COEFFICIENTS BETWEEN TWO TYPES OF TEST IN COLLEGE PHYSICS
Physics 103A, Semester I, Western Michigan College, 1954–55

	Section	N	Units and Definitions	
			Mechanics	Final
General—Mechanics	1	41	.56††	.25
	2	24	.71††	.69††
General—Final	1	41	.59††	.70††
	2	24	.75††	.85††

†† Significant at the the 1% level.

methods of the course, with the type of examination and the expected achievement standards; the final examination items were more representative of the permanent learning aims; and both parts of this test were written on the same day so that the systematic errors were constant for both variables.

4. Conclusions

The data of this investigation appear to support the conclusion that there is a fair to good correlation between a knowledge of definitions and units and achievement in elementary college physics.

It *cannot* be concluded from this study that a knowledge of units and definitions will obviate the need of stressing other fundamental aspects of the subject. It is more than likely that drill on principles and their applications has a reciprocal effect on the mastery of definitions and units. However, it is most improbable that a student really understands a principle of physics without knowing the meaning of the terminology used in the statement of the principle.

"Gentlemen, define your terms!" is a good rule to follow in a debate as well as in a physics classroom.

ANOTHER ENCOUNTER WITH GEOMETRIC SERIES

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In my paper entitled "On the Generalization of Simple Scientific Problems," which appeared in the issue of this *Journal* for January, 1953, I called attention to an encounter with geometric series which occurs in the solution of a problem connected with vacuum pumps. The spirit of that paper lives on in this one and while the results here are unexpected they are certainly welcome. They enable me to speak briefly about two unusual topics: the ***greatest integer function*** and ***geometric series with two ratios.****

Perhaps, gentle reader, you have heard of this problem—one of obscure origin:

Two cars face each other at the opposite ends of a stretch of straight highway of length (a). At the same instant, the cars start travelling toward each other, each travelling at the constant rate (c). A carrier pigeon starts with one of the cars and flies back and forth between the cars. It flies at the constant rate (p). Find (d), the distance the pigeon has flown by the time the cars crash.

Since each car travels the distance $a/2$, we find $a/2=tc$, where t is the time of flight, and, since $d=pt$, we have

$$d=pa/2c. \tag{I}$$

We note, incidentally, that if $p<c$, the pigeon would have to fly the distance $a/2$ to *land on a car*.

The problem can be *generalized* in the following manner. Let:

c_1 = the speed of the car (C_1) on the right,
c_2 = the speed of the car (C_2) on the left,
$p=p$
d_1 = the distance travelled by the pigeon before landing on C_2 after having started with C_1.

Then the total flight, d, is

$$d=\sum_{i=1}^{\infty} d_i,$$

where d_i has the obvious definition.

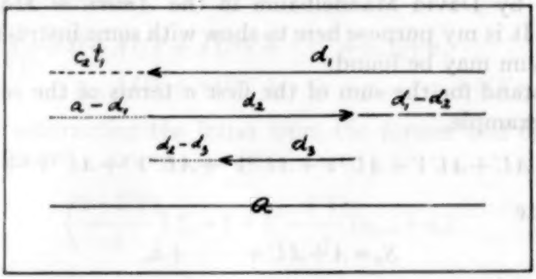
The *short* solution is effected by noting that $c_1t+c_2t=a$ and $d=pt$, which together yield

$$d=\frac{ap}{c_1+c_2}, \tag{II}$$

* Parts of this paper were included in an address, on the subject of geometric series with two ratios, delivered by the author at Rose Polytechnic Institute at the May, 1954 meeting of the Indiana Section of the Mathematical Association of America.

and we note, as a check, that this solution reduces to (I) if $c_1 = c_2 = c$.

Of special interest, however, is a longer solution—a solution which curiosity or unwariness might prompt one to attempt. As is so often the case, a figure proves to be helpful.



Now $d_1 = pt_1$. In this stage, C_2 and the pigeon must cover the distance (a) and hence $a = t_1(p+c_2)$. These two equations yield

$$d_1 = \frac{ap}{p+c_2}.$$

In the second stage, $d_2 = pt_2$ and from the figure we easily see that $c_1(t_1+t_2) = d_1 - d_2$. These equations yield

$$d_2 = \frac{p-c_1}{p+c_1}(d_1).$$

We notice the condition $p > c_1$, *i.e.*, the pigeon must move faster than C_1.

In the third stage, $d_3 = pt_3$ and, again from the figure, $c_2(t_1+t_2+t_3) = (a-d_1)+(d_2-d_3)$. It follows, then, that

$$d_3 = \frac{p-c_2}{p+c_2}(d_2).$$

If we now let

$$d_1 = A$$

$$\frac{p-c_1}{p+c_1} = U$$

$$\frac{p-c_2}{p+c_2} = V$$

and if we *assume* that the terms d_i are formed according to the law suggested by the first three terms, we must find

(III) $d=\sum_{i=1}^{\infty} d_i = A+AU+AUV+AU^2V+AU^2V^2+AU^3V^2+\cdots.$

The appearance on the scene of this series was a pleasant surprise for me—for I had already summed it subsequent to the statement of a problem by David Mandelbaum in the *American Mathematical Monthly*†. It is my purpose here to show with some instructive detail how that sum may be found.

Let S_n stand for the sum of the first n terms of the series (III). Then, for example,

$$S_8=A+AU+AUV+AU^2V+AU^2V^2+AU^3V^2+AU^3V^3+AU^4V^3.$$

I now write

$$S_n=A+AU+\cdots+a_n$$

and it is possible for me to prove that
$a_n=AU^pV^q$, where

$$\text{(IV)}\qquad p=\left[\frac{n}{2}\right] \quad\text{and}\quad q=n-1-p;$$

the number $[x]$ is the greatest integer in x, *i.e.*, it is the integer which satisfies the inequality

$$[x]\leqq x<[x]+1.$$

Now, (IV) must agree with the rule of formation of the terms in (III) and it is this agreement which must be demonstrated.

According to (IV), then, $a_{n+1}=AU^sV^t$, where

$$s=\left[\frac{n+1}{2}\right]$$

and $t=n-s$. Can this be shown to produce the proper results? For example, if p and q were equal, then s would be greater than p by unity and t would be equal to p. In order to demonstrate the validity of (IV) I consider two cases: n even, n odd.

Let $n=2r$. Then, by (IV), $a_n=a_{2r}=AU^rV^{r-1}$. We *should* have, therefore, $a_{n+1}=AU^rV^r$. This we happily find to be the case if (IV) is applied.

Now, if n is odd, say $n=2m+1$, then $a_n=a_{2m+1}=AU^mV^m$ by (IV) and, if all is to be consistent with (III), this term *should* be followed by $AU^{m+1}V^m$. If we now apply (IV) and let $n+1=2m+2$, we find that $a_{n+1}=AU^{m+1}V^m$.

† Ferrel Atkins' solution of this problem (E981) was the one later published in that journal on pp. 250–251 of the issue of April, 1952.

Finally, it is easy to see that the rule in (IV) checks for $n=1$ and $n=2$. Thus the forms of p and q as given in (IV) have been verified.

The problem which now faces us is that of finding a concise expression for S_n. Taking a cue from the well-known manner in which this is accomplished in the case of "ordinary" geometric series (those with but *one* ratio), I write

$$\begin{aligned} S_n &= A+AU+AUV+AU^2V+\cdots+a_{n-1}+a_n \\ (UV)S_n &= \quad\quad\;\; AUV+AU^2V+\cdots+a_{n-1}+a_n+UVa_{n-1}+UVa_n \end{aligned}$$

and, after subtracting the latter from the former and dividing by $A\neq 0$, we have

$$\left(\frac{1-UV}{A}\right)S_n=1+U-\frac{UV}{A}(a_{n-1}+a_n).$$

It is now possible to put S_n into several forms; a useful one in the present circumstances is shown in

$$\left(\frac{1-UV}{A}\right)S_n=1+U-(UV)^a-U(UV)^b,$$

where

$$a=\left[\frac{n+1}{2}\right] \quad \text{and} \quad b=\left[\frac{n}{2}\right].$$

This form of the result enables us to see readily that, for $|UV|<1$, $(UV)^a\to 0$ and $(UV)^b\to 0$ as $n\to\infty$.

Hence

$$\text{(V)} \qquad S_n\to S_\infty=(A)\frac{1+U}{1-UV}.$$

Now, in the case of our mixed-up pigeon, *i.e.*, in the present analogue to (III), it is easily seen that (V) does indeed reduce to the result (II). In the analogue, in fact, $0<UV<1$.

Also, for the geometric series with a first term A and a fixed ratio U, it is well-known that, for $|U|<1$,

$$S_\infty=\frac{A}{1-U},$$

and it is interesting to note that this is but a special case ($U=V$) of the more general result (V). (In our analogue, this happens when $c_1=c_2$.)

Furthermore, the precise verification of the assumption that the (d_i) are formed according to the law suggested by the first three

terms constitutes a neat problem in *mathematical induction*, the solution of which I shall forego.

Finally, is it possible to find an analogue to (III) which does *not* admit of the type of simple solution effected in the present case (II)?

MORE EFFECTIVE SELECTION AND EVALUATION OF AUDIO-VISUAL MATERIALS

ROBERT E. SCHREIBER
Northern Illinois State Teachers College, De Kalb, Ill.

In a field that has generally defied specific definition, that of audio-visual education, there is probably no one area where there have been any fewer standards agreed upon than in the selection and evaluation of materials. As a result, the process of effectively evaluating audio-visual materials has been, for most teachers, difficult and unrewarding.

Today, with few exceptions, audio-visual materials are produced and evaluated with general standards devised long ago for the appraisal of textbooks and other similar materials. Such standards direct attention to authenticity of content, appropriateness to student interest and development at various age levels, and to integration with specific school subjects. The same standards are applied to textbooks, maps, motion pictures, filmstrips, and other materials irrespective of the diverse character of these individual mediums of communication.

Under existing conditions of evaluation, as might be expected, there is little incentive to produce materials that realize the best potentialities of their particular mediums. The producer of motion pictures attempts to treat as great a variety of topics as his production schedule will permit with little regard to how well such topics may be handled in the motion picture medium. The producer of filmstrips, acting as if he hoped the teaching tool of tomorrow would be the filmstrip, likewise tends to cover a variety of topics irrespective of the characteristics of the filmstrip medium. And so it goes with recordings, educational radio programs, and other materials.

Naturally, for every error of judgement in production, there have been comparable errors in the selection and use of the various audio-visual materials by teachers. The errors on neither side have been deliberate. The factor of common sense appraisal has simply been overlooked in the majority of cases.

Perhaps it is plain by now that this observer regards a practical

appraisal of each kind of material in terms of its obvious physical characteristics as an important key to more effective selection and evaluation of audio-visual materials. Let's start off with one of the audio-visual materials available and see how this approach works.

The motion picture's principle contribution to education, as respectable research revealed over twenty-five years ago, is to present information in which motion is essential to understanding. Since, however, the motion picture is not the sole means of presenting motion for study—field trips, experiments, demonstrations, and working models also having this characteristic in common, it should be pointed out that the motion picture can reproduce any action at any time as desired. In addition to reproducing action that can be seen, through time lapse, slow motion, and animation, other action can be revealed as with no other learning aid.

However obvious it may seem at this reading that the primary contribution of the motion picture is to present motion, both the fact and the available research appear to have been ignored up to the present time. As a result we see every imaginable kind of material reproduced extensively in educational motion pictures irrespective of whether there is any motion inherent in the material or related to its understanding. The motion picture is used to reproduce static maps, graphs, charts, blackboard illustrations, still pictures, and as a means of viewing buildings, landscapes, art objects, and the like. It would be difficult, of course, to eliminate all static material from any motion picture production, even if this should prove desirable. What we have reference to here, on the other hand, is the production of films dealing more or less exclusively with such static objects and materials.

Finding the motion in a potential motion picture teaching tool is an important step toward more effective evaluation and selection. Another necessary step is to concentrate on the importance of the pictures in the motion picture. Most educational films today are sound films. Many are illustrated lectures. The lecture is usually well organized and the pictures may or may not be well integrated with it. But, the motion picture is primarily a visual medium, as research points out. Its primary contribution is to present motion, and it does this with its pictures—not with its sound track. Consequently, the pictures in motion and with good pictorial continuity should be of first consideration. The sound track can be a valuable accompaniment—clarifying, identifying, adding natural sound effects for greater realism. If it is desirable to reproduce at length the remarks of someone other than the teacher or pupils, a motion picture is hardly the most efficient means of doing this when three forms of sound recording are readily available.

Finding the motion and the picture in a potential motion picture teaching tool is often difficult. Where this is true, a motion picture under consideration clearly has failed in its main contribution, and the teacher does well to seek for better films on the same subject or utilize other kinds of available material.

The fact that audio-visual materials are teaching tools for use by teachers is one that frequently escapes both producers and some teachers. The illustrated lecture type film is, among other things, an example of such hazy thinking. The teacher needs a variety of tools with different characteristics to assist him in communicating adequately with his students. He does not need something to replace him or someone else to do his thinking for him. Any kind of audio-visual material for school use must be made with the role of the teacher in mind. To do otherwise is to produce materials that do not realize their maximum potential and which are inflexible to use.

When evaluating filmstrips for classroom use, the teacher does well to recognize that a visual medium for the presentation of still pictures in a set order is basically what a filmstrip is. It is not a suitable medium for presenting extensive caption material at the expense of pictorial quality and continuity. If reading is the order of the day, other mediums better suited to such material should be used. Neither is the filmstrip the best medium for presenting pictures of things or events where variety of sequence is desirable or necessary. Many teachers know how often they have wished that certain filmstrip pictures were available instead as individual slides even though the cost might be somewhat more. The filmstrip is a splendid means of presenting a series of still pictures in sequence. It does not convey motion any more than any other form of still picture. It is not a proper vehicle for a caption lecture. In terms of other kinds of materials available, such conclusions are valid.

Although the radio program and similar material presented by means of tape and disc recording have many useful contributions to make, it should be clear that one cannot teach many subjects successfully through sound alone. To the sophisticated adult who has had a variety of experiences to which to refer to give meaning to new facts which he hears, the relative impotence of sound as a means of presenting new knowledge to young people is sometimes hard to recognize. The adult learns much of what he knows by listening. With the young, it is essential to provide more concrete materials in conjunction with sound experiences for optimum learning. Radio writers learned long ago that "sight gags" did not go over on radio programs, just as writers today have been re-appraising the effectiveness of "sound gags" on television programs. Whether it is an appreciation of

a good joke or the dimensions of a rectangle, the proper medium, visual or auditory, must be employed.

The selection and evaluation of audio-visual materials becomes easier and more effective as the teacher recognizes the necessity for appraising individual materials in terms of the particular mediums of communication they represent. At the same time, it is essential to recognize the basic relationship of all kinds of teaching materials to the teacher and of the relationship each kind of material bears to all other kinds.

When new materials are evaluated first of all in these terms and pass these tests, it is certainly important to assure oneself of the authenticity of the content presented and to determine the proper grade and subject placement. But let us get the horse before the cart and not vice-versa.

It is to be hoped that as teachers arrive at more workable standards for the selection and evaluation of audio-visual materials, a better quality product will result. When producers are able to prepare materials that are the best use of the mediums in which they specialize, secure in the belief that their materials will be judged in such terms, a more satisfactory situation for producers and users is bound to occur. The development of impartial and realistic standards is clearly the obligation of the teaching profession. Give it your best thought!

BETTER SCIENCE TEACHING

Cornell University will use a du Pont grant to try to stimulate better science teaching in the high schools.

The fund will create special fellowships intended to encourage science students to enter science teaching and to help science teachers to take advanced study.

One group of fellowships will give full tuition and $1200 toward expenses to "science majors" from liberal arts colleges who plan to spend 1955–56 at Cornell in courses leading to full certification for secondary school teaching and a master's degree.

A second group will cover full tuition and certain expenses for secondary school science teachers who wish to use the 1955 Cornell summer session for advanced work.

The announcement said du Pont, in making the grant, had recognized Cornell's long interest in science teaching and the unusual degree of collaboration between its School of Education and its science departments.

The master's degree program will include the professional courses required for teacher certification and science courses necessary for teaching the various sciences in the secondary school.

The summer program will include special lectures, demonstrations and discussions in physics, chemistry and other sciences, together with trips to research and production laboratories. Attention will also be given to special projects and to various teaching techniques and materials.

Both programs will be under the general direction of Prof. Philip G. Johnson of the School of Education, to whom inquiries should be addressed.

HOW WILL OUR CHILDREN LEARN CONSERVATION?

Raymond G. Kenyon*
State Teachers College, Fredonia, New York

The rate of technological and industrial growth has been rapid in the past half century. The American school has accomplished much in adapting itself to an ever-changing society. The question still remains however, can we accept the responsibility for accomplishing an even better job in educating our young citizens with conservation concepts.

The general public has gained a growing consciousness regarding the problem of conservation of our resources. This public realizes, as never before, that most of our resources are not inexhaustible. In the West valuable topsoil is being lost in landslides; in the Midwest the wind is again eroding the soil; in the East constant rains have leached the soil; and in the Northwest burned over and dissipated forests are no longer as productive as before.

Those who assume leadership in the conservation movement have felt that one way of attacking the problem of conservation is to have children of school age made aware of its importance. A multitude of pamphlets and books have been written on the subject of conservation for adult consumption; but unfortunately materials for children have been limited. The elementary school teacher without previous training in conservation may be somewhat reluctant to teach conservation because of this lack of materials and equipment. Many more teachers feel a personal inability in this area of the curriculum because of the lack of formal preparation. These teachers require confidence as they begin their work in conservation education with children.

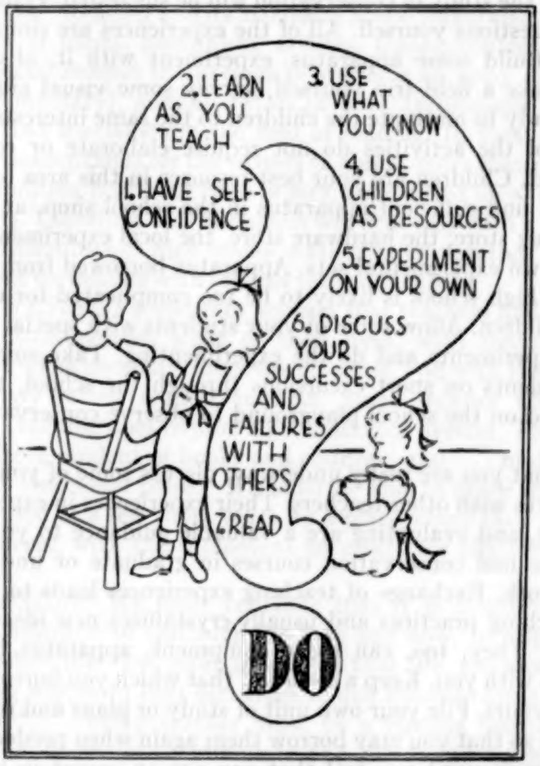
If you ask yourself, "Has my preparation for teaching conservation been adequate?" your answer will undoubtedly be in the negative. Few teachers of elementary school children have an adequate background in all of the sciences. There has been neither the time nor the breadth of courses in undergraduate or graduate education to provide them the necessary background. Even the teacher with the so-called inadequate background in conservation can do a good job of teaching by just starting to teach conservation. If you are convinced that conservation is necessary, and you know how children learn, you are able to approach this area of learning.

Begin teaching conservation with self-confidence. The teaching and learning in this area of the curriculum is essentially the same as other content areas. It is perhaps one of the easiest areas to approach for it deals with the natural environment which the child views to and

* Science consultant, New York State Education Department.

from school everyday. In fact, the areas of conservation are of real interest and concern to most children.

It is unlikely that you are a conservation specialist, nor are you expected to be one. Learn as you teach. Evolve an environment in which children can find answers to their questions. Use the subject content you are familiar with to help children answer some of their questions. Do not dictate, this assumes you know all the answers.



Initiate your teaching of conservation with an area that you are familiar with. Perhaps an interest, a hobby or specialized field of science has given you a background in one of the areas of soil, water, forest, mineral, wildlife, or human conservation. Once you have gained momentum, learn with the children.

They can broaden the area of study and initiate new problems to approach. Planning with them makes you a member of their learning group.

Subsequent to group agreement on an area or unit of study, gather a few reference books, periodicals, basic textbooks, teachers'

manuals, state courses of study, research studies, U. S. Office of Education bulletins and *read*. These materials have evolved through time-tested experiences and have been used by good teachers. Furthermore, by browsing and reading these printed materials you will begin to crystallize conservation content background that will lend security to your teaching.

In many of the references, experiments, activities, and experiences related to the study of conservation will be suggested. Follow some of these suggestions yourself. All of the experiences are simple and enjoyable. Build some apparatus, experiment with it, observe thoroughly, take a field trip yourself, survey some visual aids and you will be ready to motivate the children to the same interests.

Most of the activities do not require elaborate or complicated equipment. Children are your best resource in this area of teaching. They can find sufficient apparatus in the school shop, at home, the corner drug store, the hardware store, the local experimental station or their own experimental sets. Apparatus borrowed from the junior or senior high school is likely to be too complicated for elementary school children. Allow some of your students with special interest to set up experiments and do the experimenting. Take some of these same students on short excursions through the school, around the school and on the school playground to observe conservation or the lack of it.

Now that you are really underway, discuss some of your successes and failures with other teachers. Their experiences in experimenting, observing, and evaluating are a valuable guidance to you. Perhaps they have had conservation courses in graduate or undergraduate college work. Exchange of teaching experiences leads to familiarity with teaching practices and usually crystallizes new ideas for those involved. They, too, can share equipment, apparatus, books, and materials with you. Keep a record of that which you borrow and that which is yours. File your own unit of study or plans and return other materials so that you may borrow them again when needed.

Don't wait until you feel that you are an expert in the field of conservation. By approaching the teaching of conservation with self-confidence; learning as you teach; beginning with what you know; reading for background; experimenting by yourself; using easily found, simple equipment; using children as resources; discussing your successes and failures with others; children will profitably learn acceptable conservation concepts.

Plaid decals are in giant sheets of plastic to use in self-colorizing your car. Weather-resistant with an enamel-like finish, the Scotch-plaid decals can be easily applied to an auto's roof-top or fenders and just as easily removed.

A MATHEMATICAL ATTACK ON THE READING PROBLEM

BELLE W. SMITH AND ARTHUR C. HEARN
University of Oregon, Eugene, Ore.

THEOREM: Reading and its attending obstacles furnish the theme for myriads of books, pamphlets, articles, theses, conferences, and group projects. Behind the barrage of words is an army of teachers (usually elementary), administrators (a few), technicians (for clinical cases), and specialists in the field of reading. In view of this, it would be presumptuous for the writers to aim at more than one point, using ammunition borrowed from others, augmented by a few home-made pellets. Therefore, this discussion will deal only with a summary of reading difficulties in high school mathematics, together with suggested means for dealing with some of these difficulties.

HYPOTHESIS: It sometimes appears that teachers find pupils at the most distintegrated stage of their lives, with memory functioning only when pleasant things are involved, and with the unessential seemingly rating highest interest. Small wonder that Betts[1] says . . . "Teaching does require a good nervous system. The teacher must be a keen student of books and children, and . . . must be able to maintain emotional poise." We must be able to guide our pupils, within a period of a few short years, to a place where they can enter the adult world, with the equipment necessary for effective citizenship.

CONCLUSION: We must conclude that it is a duty of every teacher, in addition to enriching life here and now, to help prepare pupils for adult life—the more successful that life, the more important reading will be in that life. High school teachers must be made aware that " . . . every teacher must be a reading teacher in the sense that he or she must stimulate and direct the experiences of pupils and promote increased efficiency in the various reading activities."[2] Most investigators agree that in high school the ability to read is specific to the area of subject matter. Agnes Boner[3] states that "High school pupils will read better only when every teacher assumes the responsibility of teaching them to read the materials in his course, when every teacher is aware of reading difficulties, and when every teacher helps his students to define purposes for all reading tasks." Because teachers of content subjects must teach

[1] Betts, Emmett A., Foundations of Reading Instruction. New York: American Book Company, 1950.

[2] Schaper, Helen Elizabeth, *A Reading Program in the Junior High School Grades*. Unpublished Master's thesis, University of Oregon, Eugene, 1941.

[3] Boner, Agnes, "How Can We Help the High School Child to Read Better?" *Montana Education Association Journal*, 28: 11, 26, February, 1952.

their pupils to use the skills and techniques necessary to read the materials of their subjects, the writers propose the following guide for the consideration of teachers in the field of mathematics.

Statement of Difficulties	*Proposed Methods of Attack*
I. Reading difficulties growing out of the pupil's methods of attack.	I. Use one of the following:
A. Lack of understanding due to superficial reading.	A. Before the pupil attempts the solution of a problem, have him write, concisely, the answer to these questions: 1. What am I told? 2. What am I to find?
B. Misinterpretation due to lack of precision in reading.	B. Have every problem read aloud when beginning a new type of problem, and have its full meaning ascertained before the class begins work.
C. Difficulty due to failure to study an accompanying illustrative example.	C. Where possible, require the pupil to draw a diagram before the solution is attempted.
D. Mechanical following of directions without gaining understanding of the mathematical process which the directions are designed to teach.	D. For new material, have pupils take turns teaching the method to the class through the use of the illustrative solution in the book.
E. Mechanical reading of formulas without comprehending the concrete ideas they symbolize.	E. In studying a formula, consider the symbols in relation to the words. Keep the full written formula on the board during the development of the lesson. Pupils benefit from actual geometric figures (boxes, paper cones, cylindrical cartons, balls) with appropriate symbols printed on them, in learning formulas. Whenever a concrete example can be used, it should be included. Some of the students will be able to suggest ways of showing formulas graphically.
F. Misinterpretation due to failure to relate problem to accompanying explanatory material.	F. Have pupils state what part of the problem represents each item of the illustrative material before starting the assignment. Use illustrative problems in developing new concepts. Teach for "transfer."

Statement of Difficulties	*Proposed Methods of Attack*
G. Misinterpretation due to disregard for punctuation and for key words or phrases.	G. Problems in assignments should be stated in a variety of forms. Evaluation should consider the various steps in problem solving in addition to the final result.
II. Reading difficulties due to inability to recognize relationships.	II. Use any of the following methods:
A. Inability to associate descriptive material with accompanying mathematical figures.	A. Spend considerable time going over illustrative material. Methods I C, D, E, and F are all applicable.
B. Inability to associate directions with accompanying explanatory materials.	B. Method I D.
III. Reading difficulties arising from lack of knowledge of subject matter.	III. Use one of the following:
A. Failure to master preceding mathematical concepts.	A. Begin each day's work with a short review of the pertinent mathematical terms, processes, or principles.
B. Lack of understanding of the mathematical process used.	B. Method I D. Whenever start- new material, go slowly. The solution of early three problems thoroughly understood is better than thirty half understood.
C. Inability to comprehend the mathematical relations involved.	C. Method III B.
IV. Reading difficulties caused by deficiencies in vocabulary.	IV. Use one of the following:
A. Lack of understanding or misinterpretation of mathematical vocabulary.	A. Have pupils keep a mathematical vocabulary note-book. Have frequent vocabulary drills.
B. Application of incorrect meanings to symbols.	B. Method IV A. Include symbols in vocabulary.

In the preceding statements the writers have attempted to suggest means by which the teacher might:

1. Guide pupils in reading skillfully,
2. Guide pupils in appraising critically the content of what is read,
3. Guide pupils in the use of ideas gained from reading.

Since these goals lie in a horizontal plane that cuts across many areas of subject matter, even a moderate improvement in reading ability in mathematics should improve the pupil's reading ability in other areas.

SEMI-MICRO PROCEDURE IN HIGH SCHOOL LABORATORIES

KARL J. AABERG
Mankato Senior High School, Mankato, Minn.

In July of 1941 our high school burned, destroying all of our chemistry equipment. The next ten years were spent in a junior high school building with very poor laboratory facilities. Since we had not planned on a decade in this building, we kept our chemistry equipment to a bare minimum.

In September, 1951, we were to move into our new building with fine chemistry facilities. The question in equipping the new laboratories was whether to order equipment for macro or for semimicro chemistry. We consulted the chemistry instructors at Mankato State Teachers College and salesmen of scientific equipment, and after seriously considering their suggestions we decided upon semimicro.

We had to pioneer in this work, as no school in this state or nearby states used the semimicro method for laboratory work; thus, we were the first school in the state to use semimicro in the high school.

The first problem was to find a manual. After writing to the major publishers, the best manual we were able to locate was one written by Schiller, O'Donnell and Morrison and published by the Globe Book Company of 175 5th Avenue, New York 10, New York. We ordered the manual, then proceeded to make out the list of equipment and chemicals needed for 75 students with the generous help of Dr. L. A. Ford of the Mankato State Teachers College. Our order amounted to slightly less than $1100 for seventy-five students; this amount included $210 for a water still. Had we ordered equipment for the macro method we would have spent twice that amount.

Having taught chemistry by the macro method for twenty-one years I was sure I would learn much with this new method. My first observation was how slowly the students seemed to work. The reason for this seemed fairly obvious. In the macro laboratory the students had worked in pairs, hence, the experiment moved faster; now they were working individually. Our laboratory is equipped to handle thirty-two students in each class, so there were thirty-two individuals, each doing his own work.

During the summer of 1951 I spent ten weeks at the University of Colorado where I tried to find more information about the semimicro method. There is litttle available. I did find another manual published by the D. C. Heath & Company, written by Fred T. Weisburch. However, I should state that this manual, as all others, has too many experiments. It would be better for the instructor to write his own manual if he has the ability and time to do the work.

In my opinion, there are three methods of teaching semimicro laboratory. First, a set of chemicals may be made for each student to keep in a tray in his desk. This method is described in the *Clearing House Magazine* for May of 1953 by Fred B. Eisemen, Jr. of John Burroughs School, Clayton, Missouri. This seems to require more extensive supplies than are normally needed besides dozens of man hours of preparation. Of course, after the work is done it gives each student an opportunity to stay at his desk for concentrated work and gives the instructor more time for supervision.

The second method is to use a set of chemicals in trays for each table. In our own case I would need at least four trays; eight would be better. This is the method recommended by the two manuals. This method would require many hours of bottle filling and labeling at the beginning of the year. It is true that competent students can be used to help do the necessary work in the two methods I have just explained. Either of these methods cuts down on laboratory traffic and makes supplies available close at hand. The second method is used at the Owatonna, Minnesota High School and is working very satisfactorily according to Mr. Collins, the instructor.

The third method is the one I use. Having 4 laboratory desks in the laboratory with 8 students at each desk, I have 4 supply stations, one for each desk. For each experiment the necessary supplies are placed at each station. The liquids are placed in 250 cc. brown dropper bottles and the soilds in 2 ounce screw cap bottles. For doing about 35 experiments and using four stations 280 250 cc. dropper bottles are needed for the solutions and approximately one and one-half gross of 2 ounce screw cap bottles for the solids. I have 4 balances capable of weighing to .01 of a gram, one for each station.

Our laboratory has two centifuges; there is no filtering with semimicro. We also have adjustable steel stools for each student; with semimicro, stools are an asset to more efficient work.

Semimicro, in my opinion, is more desirable for the following reasons: (1) it is much cheaper to operate; (2) each student works individually, thus getting more out of the experiment; (3) there is less danger of explosions and acid burns because of the small amounts of chemicals used as compared with macro; (4) results are at least just as evident and in most cases more evident than in macro because of

accuracy; (5) less offensive odors result from smaller amounts.

Wisconsin high schools, both public and parochial, are rapidly changing to semimicro, and in Minnesota the change is becoming evident, especially where new buildings are being built.

I have checked my classes these past three years and find they are well satisfied with the method. The most common answer is, "I can do it myself and work at my own speed." I grant they have never worked the macro method but from their reactions I am sure they wouldn't care to use it.

In conclusion may I ask, why not try this new method? Why use cubic centimeters when a few drops do the same, or why use grams when a spatula full gives the same results? Medicine droppers, spatulas, microscope slides, 10 mm. test tubes, 50 ml. beakers, 50 erlenmeyer flasks, micro burners, etc., are more interesting to use than the large cumbersome, expensive macro equipment. Why not be a starter instead of a follower? Try it. You and your students are in for a new lease on chemistry, in the laboratory.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING

Harris Teachers College, St. Louis, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, Harris Teachers College, St. Louis, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Solutions should be in double spaced typed form.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known reference to it.

4. Each solution or problem for solution should be on a separate page.

In general, when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

2432. *Rueben Barrick, Chambersburg, Pa.*

2432. *Washington Conn, Cashtown, Pa.*

2432. *Edward Van Piper, Gettysburg, Pa.*

2441, 2443, 2444, 2447, 2448. *C. W. Trigg, Los Angeles, Calif.*

2442, 2447. *Felix John, Philadelphia, Pa.*

2443. *Herbert Wolf, Chicago, Ill.*

2444. *Marian Craig, Felton, Calif.*

2444, 2447, 2448. *J. Byers King, Denton, Md.*

2446, 2447. *Millard E. Agerton, Preston, Ga.*

2446. *Nancy Hunter, Oberlin, Ohio*

2447. *Leon Bankoff, Los Angeles, Calif.*

CORRECTION: ***Problem 2456 which appeared in the March issue should have had a minus (−) sign between the two terms in the denominator of the fraction.***

AN INEQUALITY

2449. *Proposed by Dewey C. Duncan, Los Angeles, Calif.*

For any positive rational value of $n>1$; show $n^n>(n+1)^{n-1}$.

Solution by the Proposer

Proof lies in showing that $n^n-(n+1)^{n-1}>0$.

$$n^n-(n+1)^{n-1}=n^{n-1}\left\{n-\left[1+\frac{1}{n}\right]^{n-1}\right\}$$

$$=n^{n-1}\left\{n-\left[1+\frac{n-1}{n}+\frac{(n-1)(n-2)}{2!n^2}+\frac{(n-1)(n-2)(n-3)}{3!n^3}+\cdots\right]\right\}.$$

Case I. Let n be an integer. There are n terms of the expansion within the [brackets], each term after 1 being less than n. Therefore the sum within the brackets is less than n; wherefore the total within the {braces} is positive.

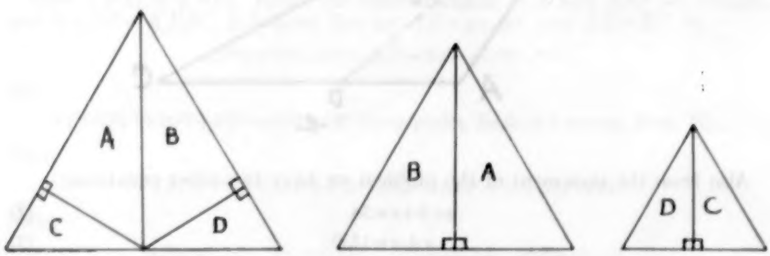
Case II. Let n be an improper fraction and $N<n<N+1$, with N an integer. Again, the $N-1$ leading terms of the expansion within the [brackets] are each less than 1, except the leading term which is 1. Following after these $N-1$ terms is an alternating series the first term of which, being positive, is

$$\frac{(n-1)(n-2)\cdots(n-N)}{N!n^N}$$

and is itself less than 1. Therefore the sum of this alternating series is less than 1. Therefore the sum of all terms within brackets is less than n; wherefore again the total within {brackets} is positive.

DISSECTING AN EQUILATERAL TRIANGLE

2450. *Proposed by C. W. Trigg, Los Angeles, California.*



Show how to dissect an equilateral triangle by straight cuts into four pieces which can be reassembled to form two triangles similar to the given triangle.

Solution by Charles H. Butler, Kalamazoo, Michigan

First draw the bisector of one of the angles of the original triangle, thus dividing it into two congruent right triangles. Then from the vertices of the right triangles thus formed, draw perpendiculars to the other two sides of the original triangle. Cut along the lines drawn and reassemble as shown above.

A solution was also offered by J. J. Wickham, Yonkers, N. Y.

2451. *No solution has been offered.*

A TRIANGLE PROBLEM

2452. *Proposed by Bro. Felix John*

In triangle ABC the perimeter is 36, $t_b = \frac{3}{2}\sqrt{85}$ and $a \cdot b \cdot c = 1530$. Find a, b, and c.

Solution by Clinton E. Jones, Tennessee A and I State University, Nashville, Tennessee

From elementary geometry, the bisector of an interior angle of a triangle divides the opposite side internally into segments having the same ratio as the other two sides of the triangle. Therefore, we have

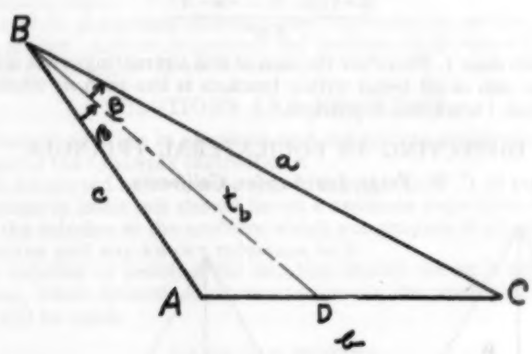
$$AD = \frac{bc}{a+c} \quad \text{and} \quad DC = \frac{ab}{a+c}.$$

Applying the cosine law to triangles ABD and DBC we have

$$\cos B = \frac{c^2 + t_b^2 - \left(\frac{bc}{a+c}\right)^2}{2ct_b} = \frac{a^2 + t_b^2 - \left(\frac{ab}{a+c}\right)^2}{2at_b}.$$

Simplifying we obtain

$$(a+c)^2 \cdot (ac - t_b^2) = ab^2c. \tag{1}$$



Also from the statement of the problem we have two other equations:

$$a+b+c = 36 \tag{2}$$

$$a \cdot b \cdot c = 1530. \tag{3}$$

Substituting in (1) from (2) and (3) we have,

$$(36-b)^2\left(\frac{1530}{b}-t_b^2\right)=1530b.$$

Squaring, substituting for t_b and simplifying we obtain

$$8b^3-576b^2+16200b-104976=0.$$

From this equation we conclude that $b=9$ and finally that $a=17$ and $c=10$.

Solutions were also offered by Richard H. Bates, Milford, N. Y.; A. R. Haynes, Tacoma, Wash.: Stinson McDuffee, Montgomery, Ala.; Walter R. Warne, St. Petersburg, Fla.; and the proposer.

2453. *No solution has been offered.*

RELATION BETWEEN THE SIDES AND PERPENDICULAR DIAGONALS OF AN INSCRIBED QUADRILATERAL

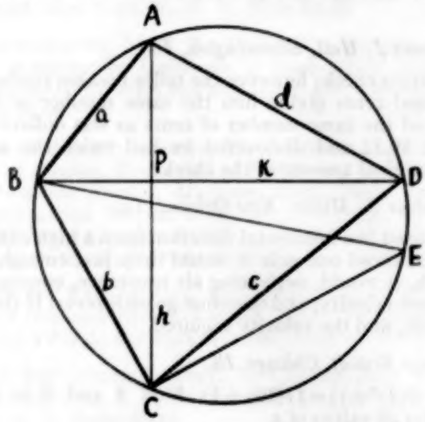
2454. *Proposed by Leon Bankoff, Los Angeles, Calif.*

A quadrilateral with sides a, b, c, d, is inscribed in a circle of radius R in such manner that the diagonals h and k are mutually perpendicular. Prove that

$$abcd=R^2(h^2+k^2-4R^2).$$

Solution by the Proposer

Let $AC=h$ and $BD=k$. Call their point of intersection P. Then $AB=a$, $BC=b$, $CD=c$, and $DA=d$. Draw the diameter BE and the chord CE.



Now $\measuredangle BAC=\measuredangle BEC$. Hence the right triangles BCE and ABP are similar, and $\measuredangle ABD=\measuredangle EBC$. It follows that arc $AD=$ arc EC and $AD=EC$. So

$$AP^2+PD^2=BE^2-BC^2=BE^2-BP^2-PC^2,$$

and

$$AP^2+PC^2+BP^2+PD^2=BE^2=4R^2 \text{ (Archimedes, Book of Lemmas, Prop. II).}$$

Then

$$(AP+PC)^2+(BP+PD)^2=4R^2+2AP\cdot PC+2BP\cdot PD.$$

Now,

$$AP=ad/2R;\quad PC=bc/2R;\quad PD=dc/2R;\quad BP=ab/2R$$

so

$$h^2+k^2=4R^2+abcd/R^2,$$

and

$$abcd=R^2(h^2+k^2-4R^2).$$

A solution was also offered by A. R. Haynes, Tacoma, Wash.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Instructors are urged to report to the Editor such solutions.

EDITOR'S NOTE: For a time each student contributor will receive a copy of the magazine in which his name appears.

PROBLEMS FOR SOLUTION

2473. *Proposed by C. H. Butler, Kalamazoo, Mich.*

Prove that in any triangle, the radius of the inscribed circle is to the difference between that radius and the altitude drawn to a given side as the sine of half the angle opposite the given side is to the cosine of half the difference of the other two angles.

2474. *Proposed by Joseph O'Meara, St. Louis, Mo.*

Find the probability that in a bridge deck no two successive cards have the same denomination.

2475. *Proposed by Louis J. Hall, Bloomington, Ind.*

A man cashed a certain check; however the teller became confused and interchanged the dollars and cents giving him the same number of dollars as was cents on the check, and the same number of cents as was dollars on the check. The man then spent \$9.32 and discovered he had twice the amount of the check. What was the original amount of the check?

2476. *Proposed by Julius S. Miller, New Orleans, La.*

If a projectile were fired in a horizontal direction from a high cliff with a velocity such that, as it advanced one mile it would drop just enough to follow the curvature of the earth, it would, neglecting air resistance, continue around the earth with undiminished velocity, and therefore go on forever! If the earth "drops away" 8 inches per mile, find the velocity required.

2477. *Proposed by Hugo Brandt, Chicago, Ill.*

Given $A(3x^3+1)+B(2x^2+1)=17(10x+1)$. Find A and B in terms of x to satisfy the equations for all values of x.

2478. *Proposed by Oscar W. Reid, Rogers, Ark.*

Find the positive number x so that $4^8+4^{11}+4^x$ shall be a perfect square.

BOOKS AND PAMPHLETS RECEIVED

College Algebra, Revised Edition, by Paul R. Rider, Ph.D., *Chief Statistician, Aeronautical Research Laboratory, Wright-Patterson Air Force Base.* Cloth. Pages xiv+397. 13×20.5 cm. 1955. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $4.00.

General Chemistry, by L. E. Steiner and J. A. Campbell, *Professors of Chemistry, Oberlin College.* Cloth. Pages x+675. 15×23.5 cm. 1955. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $6.50.

Electronics for Young People, New Revised Edition, by Jeanne Bendick. Cloth. 189 pages. 13.5×20 cm. 1955. Whittlesey House, McGraw-Hill Book Company, Inc., 330 West 42nd Steert, New York 36, N. Y. Price $2.75.

Algebra Two, by Rolland R. Smith, *Co-ordinator of Mathematics, Public Schools, Springfield, Massachusetts,* and Francis G. Lankford, Jr., *Professor of Education, University of Virginia.* Cloth. Pages iv+506. 15×23 cm. 1955. World Book Company, Yonkers-on-Hudson, N. Y. Price $3.00.

Transform Calculus with an Introduction to Complex Variables, by E. J. Scott, *Assistant Professor of Mathematics, University of Illinois.* Cloth. Pages viii+330. 15×23.5 cm. 1955. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price $7.50.

Atoms Today and Tomorrow, by Margaret O. Hyde. Cloth. 143 pages. 13×20.5 cm. 1955. Whittlesey House, McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $2.50.

Plane Trigonometry, by C. R. Wylie, Jr., *Professor and Chairman of the Department of Mathematics, University of Utah.* Cloth. Pages viii+381. 15×23 cm. 1955. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $4.00.

An Outline of Atomic Physics, Third Edition, by Oswald H. Blackwood, *Late Professor of Physics, University of Pittsburgh;* Thomas H. Osgood, *Dean of the School of Graduate Studies, Michigan State College;* and Arthur E. Ruark, *Temerson Distinguished Service, Professor of Physics, University of Alabama.* Cloth. Pages x+501. 14.5×23 cm. 1955. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $7.50.

Science and Its Background, Second Edition by H. D. Anthony, Headmaster, *Kilburn Grammar School,* London. Cloth. Pages ix+337. 12.5×19.5 cm. 1954. St. Martin's Press, 103 Park Avenue, New York 17, N. Y. Price $4.00.

Marvels of Industrial Science, by Captain Burr W. Leyson. Cloth. 189 pages. 13×20.5 cm. 1955. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York 10, N. Y. Price $3.50.

You and Science, by Paul F. Brandwein, *Chairman, Science Department, Forest Hills High School, New York, N. Y.;* Leland G. Hollingworth, *Director of Science, Brookline Public Schools, Brookline, Massachusetts;* Alfred D. Beck, *Science Supervisor, Junior High School Division, Board of Education, New York City;* and Anna E. Burgess, *Directing Principal, Board of Education, Cleveland, Ohio.* Cloth. 630 pages. 15.5×23.5 cm. 1955. Harcourt, Brace and Company, New York, 17, N. Y. List Price $3.92.

Science and the Human Imagination, by Mary B. Hesse, *Lecturer in Mathematics in the University of Leeds.* Cloth. 171 pages. 13.5×21.5 cm. 1955. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.75.

The Elements of Chromatography, by Trevor Illtyd Williams, Oxford,

London. Cloth. 90 pages. 11.5×18.5 cm. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.75.

PRINCIPLES OF ELECTRICITY BASED ON THE RATIONALIZED SYSTEM OF UNITS, by Arthur Morley, *Formerly Professor of Mechanical Engineering in University College, Nottingham and Later H.M. Staff Inspector of Technical Schools;* and Edward Hughes, *Formerly Vice-Principal and Head of the Engineering Department, Brighton Technical College.* Cloth. Pages xiii+364. 11.5×18.5 cm. 1954. Edward Hughes, 16 Tongdean Avenue, Hove 4, Sussex, England. Price 10s. 6d.

FUNDAMENTALS OF ELECTRICAL ENGINEERING BASED ON THE RATIONALIZED M.K.S. SYSTEM OF UNITS, by Edward Hughes, *Formerly Vice-Principal and Head of the Engineering Department, Brighton Technical College,* Cloth. Pages xiv+470. 11.5×18.5 cm. 1954. Edward Hughes, 16 Tongdean Avenue, Hove 4, Sussex, England. Price 12s. 6d.

DIFFERENTIAL AND INTEGRAL CALCULUS, Second Edition, by Harold Maile Bacon, Ph.D., *Professor of Mathematics, Stanford University.* Cloth. Pages vii +547. 14.5×23 cm. 1955. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $6.00.

PHILOSOPHY AND ANALYSIS. A SELECTION OF ARTICLES PUBLISHED IN *Analysis* BETWEEN 1933–40 AND 1947–53. Edited, with an Introduction by Margaret Macdonald, *Editor of "Analysis."* Cloth. Pages viii+296. 13.5×21.5 cm. 1954. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $7.50.

DOWN TO EARTH, by Robin Place, M.A., *First Class Honours, Archaeological and Anthropological Tripos, Cambridge.* Cloth. Pages xvi+173. 13×21.5 cm. 1955. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $7.50.

THE THEORY OF NUMBERS, by Burton W. Jones, *Professor of Mathematics, The University of Colorado.* Cloth. Pages xi+143. 14×21.5 cm. 1955. Rinehart and Company, Inc., 232 Madison Avenue, New York, 16, N. Y. Price $3.75.

FLIGHT HANDBOOK, Compiled by the Staff of Flight, and Edited by Maurice A. Smith. Fifth Edition. Cloth. 282 pages. 13.5×21.5 cm. 1955. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

ELECTRONS, ATOMS, METALS AND ALLOYS, by William Hume-Rothery, O.B.E., F.R.S., *Lecturer in Metallurgical Chemistry, University of Oxford, England.* Cloth. 387 pages. 13.5×21.5 cm. 1955. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $10.00.

MODERN TRIGONOMETRY, by John C. Brixey, Richard V. Andree, *The University of Oklahoma.* Cloth. Pages xii+209. 16×23.5 cm., 1955. Henry Holt and Company, 383 Madison Avenue, New York 17, N. Y. Price $3.25.

FIRST COURSE IN ALGEBRA FOR COLLEGES, by L. J. Adams, *Santa Monica City College, Santa Monica, California.* Cloth. Pages vi+217. 13.5×21 cm. 1955. Henry Holt and Company, 383 Madison Avenue, New York 17, N. Y. Price $3.00.

EXPERIENCES IN SCIENCE. A WORKBOOK TO ACCOMPANY *You and Science,* Second Edition, by Paul E. Blackwood, *Specialist for Elementary Science, U. S. Office of Education.* Paper. 156 pages. 19×27.5 cm. 1955. Harcourt, Brace and Company, New York 17, N. Y. List Price $1.32.

TRENDS IN THE PRODUCTION OF CURRICULUM GUIDES. A SURVEY OF COURSES OF STUDY PUBLISHED IN 1951 THROUGH 1953, by Eleanor Merritt, *Iowa State Teachers College, Cedar Falls, Iowa,* and Henry Harap, *Director of Curriculum Laboratory, George Peabody College for Teachers, Nashville, Tennessee.* Paper. 43 pages. 15×23 cm. 1955. Division of Surveys and Field Services, George Peabody College for Teachers, Nashville, Tenn. Price 50 cents a copy.

UNTIL ALL SHALL KNOW, by Edwin S. Burdell, *President of The Cooper Union for the Advancement of Science and Art.* A Report to the Trustees for the Ninety-Fourth Year Ending June 30, 1954. Paper. 35 pages. 18.5×27 cm. The Cooper Union, Cooper Square, New York, 3, N. Y.

AAR RESEARCH ACTIVITIES—1954. Paper. 40 pages. 21.5×28 cm. Research Center Association of American Railroads, Technology Center, Chicago 16, Ill.

HOT-METAL MAGIC. Paper. 32 pgaes. 19×26 cm. 1954. Electro Metallurgical Company, 30 East 42nd Street, New York 17, N. Y.

EASTMAN KODAK COMPANY ANNUAL REPORT. Paper. 36 pages. 21.5×28 cm. Eastman Kodak Company, Public Relations Department, 343 State Street, Rochester 4, N. Y.

THE SCHOOL ADMINISTRATOR LOOK AT HEALTH GOALS FOR YOUTH. Paper. 14 pages. 13.5×19.5 cm. 1954. School Health Bureau, Health and Welfare Division, Metropolitan Life Insurance Company, New York, N. Y.

UNITED AIRCRAFT CORPORATION PICTORIAL REPORT. Paper. 28 pages. 21.5 ×27.5 cm. 1954.

U. S. GOVERNMENT AWARDS UNDER THE FULBRIGHT ACT. General Information. Paper. 21 pages. 14×21.5 cm. The Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Avenue, Washington 25, D. C.

TREATISE ON INTEGRAL CALCULUS WITH APPLICATIONS, EXAMPLES AND PROBLEMS. Vols. I and II, by Joseph Edwards, M. A., *Formerly Fellow of Sidney Sussex College, Cambridge, and Principal of Queen's College, London.* Cloth. Vol. I, pages xxi+907. Vol. II, pages xv+980. 11.5×20 cm. 1954. Chelsea Publishing Company, 552 West 181 Street, New York 33, N. Y. Price $6.50 per Volume.

BOOK REVIEWS

ELEMENTS OF CARTOGRAPHY, (Original Illustrations by James J. Flannery.) by Arthur H. Robinson, *Professor of Geography, University of Wisconsin.* Cloth. Pages lx+254. 18.1×25.4 cm. 1953. Wiley & Sons, Inc., 440–4th Ave., New York 16, N. Y. Price $7.00.

Auto travel has made America map-conscious. It is doubtful, however, if those map-users have given thought to the making of those maps. Cartography is dedicated to that service. Map-making, Cartography, is said to be "a mixture of science and art." This author "draws upon the abilities of the geographer, the mathematician and the artist to present (Cartography) as a science and an art." The book is expected to serve the medium and small scale map-makers but is also of much value to all who deal with or use maps.

The subject is presented in ten chapters starting with the history of Cartography. Following are: Earth and the System of Coordinates; Map Projection; Drafting, Materials and Map Reproduction; Map Base; Map Design; Map Lettering; Symbolization and Distribution Maps and Representation of Terrain. The chapter on Map Design is said to be an innovation rendering this book unique in that respect.

The English of the text is nontechnical and readily readable. The 185 figures, many of them photographic reproductions, are well captioned and contribute

much to the book's exposition. Thirty eight tables, one third of which are in the ten appendices, substantially enhance its resource worth.

For the ambitious student reference aids are offered in a four paged bibliography and a seven paged double columned index. The training, experience and status, as a geographer, inspire confidence in the author's competence.

B. CLIFFORD HENDRICKS
Longview, Washington

PICTURE BOOK OF TV TROUBLES; Vol. 1 Horizontal AFC-Oscillator Circuits, by John F. Rider Laboratories Staff. Paper. Pages vi+70. 14×21.5 cm. 1954. John F. Rider Publisher, Inc.

This little booklet reports the results of trouble shooting a large number of television receivers. It deals only with the faults that occur in a single specific unit of the receiver, the oscillator unit for horizontal scanning with its automatic frequency control feature. Four different systems are considereed:
(a) pulse width AFC-ocsillator circuit (Synchroguide)
(b) phase detector-stabilized multivibrator AFC-oscillator circuit
(c) phase discriminator-sine wave oscillator AFC-circuit (Synchrolok)
(d) phase detector-sine wave oscillator AFC circuit
A complete circuit diagram and a series of oscilloscope wave patterns at different points of the circuit for a properly adjusted and fault-free circuit are given for each of the above systems. These are followed by picture tube and oscilloscope patterns obtained in the circuit when a particular component was defective or faulty. The service technician is supposed to get a clue to the defective component or the type of fault present in the set that he is testing from the comparative patterns he obtains by connecting an oscilloscope between different points of the circuit under test. Voltmeter readings are also given to serve as a means of indicating defective components.

This booklet is designed as a pictorial guide in trouble shooting TV sets, specifically the horizontal scanning oscillator. It is a technician's service manual, not intended for general reading. The booklet has a table of contents but no index.

WALTER G. MARBURGER
Western Michigan College
Kalamazoo, Michigan

OBTAINING AND INTERPRETING TEST SCOPE TRACES, by John F. Rider. Paper. 14×21.5 cm. Pages 186. John F. Rider Publisher, Inc. 480 Canal Street, New York 13, N. Y. 1954. Price $2.40.

The first seven chapters of this book deal with the shapes of the different voltage waveforms commonly encountered in TV and radio receivers, audiofrequency amplifiers, power supplies, electronic test equipment, and amateur radio transmitters. These waveforms include simple and complex sinusoids; square, rectangular, trapezoidal, and sawtooth waveforms; amplitude modulated envelope forms; response and S-curves. The treatment is largely graphic and non-mathematical, profusely illustrated with well-labelled drawings and actual oscillograms.

The proper manipulation and adjustment of the oscilloscope controls for securing a satisfactory display of voltage waveforms under examination are discussed in detail in another chapter. A chapter is devoted to a discussion of Lissajous Figures, methods of obtaining these figures on the screen of an oscilloscope, and the use of these figures in frequency measurements.

Another chapter deals with the interpretation of distortion in waveforms observed in analyzing and servicing general electronic equipment, with special emphasis on the distortion patterns that may occur in television receiver circuits. The final chapter gives a number of test setups and oscilloscope connections for observing voltage waveforms in general and making different test measurements.

The discussions and explanations in this book are clear, concise, and easy to

follow. The illustrations are well chosen, distinctly drawn and very helpful to the reader. This book should serve as an excellent oscilloscope manual for electronic technicians and service men. It should prove to be an invaluable aid to engineers, teachers, and others who wish to become better acquainted with the oscilloscope and its practical applications.

WALTER G. MARBURGER

RELATIVITY FOR THE LAYMAN, by James A. Coleman, *Department of Physics and Astronomy, Connecticut College, New London, Connecticut.* Cloth. 131 pages. 13.5×20.5 cm. 1954. The William-Frederick Press, 313 West 35th Street, New York 1, N. Y. Price $2.75.

This is a book "written primarily for those who have had little or no training in mathematics, physics, or astronomy." Let us examine it carefully to see if it fulfills this mission. It is a small book of only seven short chapters, 127 pages in all. Just the type so far to attract the busy layman. The first chapter tells in a very interesting manner the various methods of measuring the speed of light: Galileo's unsuccessful attempt, Roemer's success making use of the first fast moving moon of Jupiter, Bradley's aberration of light method, Fizeau's cogwheel method, and Michelson's revolving mirror. Each successful method is illustrated by interesting drawings. The second chapter entitled, "The Great Dilemma," will require a little closer thought. A few of our laymen may drop out while trying to master the Michelson-Morely experiment and the explanation of the negative result by means of the Fitzgerald-Lorentz contraction. Chapter 3, on the special theory of relativity, requires still closer thinking by those without considerable experience in physics. Unless the "laymen" consist of just a few of the ordinary educated mortals they will have some difficulty in getting the idea that

$$V_{AB}=\frac{V_A+V_B}{1+\frac{V_AV_B}{C^2}},$$

or that

$$t'=t\sqrt{1-\frac{v^2}{c^2}},$$

as given in the chapter even though it is nearly as long as the two preceding chapters. Chapter 4 gives the "Experimental Proof of the Special Theory." Here the reader, in very short order, must be able to become acquainted with, or must have acquired by previous study, some of the important thought of Sommerfeld, with the splitting of spectral lines, with atomic accelerations, with nuclear binding energy, fission, fusion, and Ive's time experiment. If the layman is still with us he is now ready for Chapter 5, "The General Theory and Experimental Proof." This is a very interesting chapter for all who have kept up. They will enjoy the discussion of the general theory of relativity, of the explanation of the behavior of the planet Mercury, and the effect of gravitational mass on time. Chapter 6 discusses the types of universes and our universe as Einstein conceives it. The last chapter points out some possible developments in thought for the future. So, if you are the right type of layman, this book will be most instructive and interesting. I recommend that you try it.

G. W. W.

PHYSICS FOR OUR TIMES, by Walter G. Marburger, *Professor of Physics, Western Michigan College of Education, Kalamazoo, Michigan,* and Charles W. Hoffman, *Rocket Branch, Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland.* Cloth. 574 pages. 16×23.5 cm. 1955. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $4.48.

This is a textbook that merits your consideration. Excellent in narration, vivid in description, clear in explanation, well describes the text. The drawings are

large and show well the essentials of the principle illustrated. The language is simple and clear. Italics are used to assist the student in directing his thought to the proper items. Bold face type is used in the statement of the law or principle just discussed. Illustrative examples of mathematical solutions are given and the work completely shown.

The section on "Light" merits particular comment. The drawings are made with white lines on dark surfaces. Eight beautiful full page plates are shown in color. In many respects this text follows the usual standard outline that has become well fixed in physics: 164 pages for mechanics, 90 pages for heat, 52 pages for sound, 142 pages for electricity, 76 pages for light, and 35 pages on atoms or what some authors have called modern physics.

The authors have evidently been more intent on teaching the principles of physics than in making the subject exceedingly popular. But in some cases the principle could have been demonstrated with less work than is here demanded, if the student is to work through the problems illustrated as in Fig. 2–4. The reviewer would like to raise a question with respect to Fig. 2–12 and the paragraph describing it. Since pressure is always exerted perpendicular to the containing surface and is dependent only on the depth and density of the fluid, why talk about *average* pressure? Should not the meaning of this drawing be more fully explained? Also we wonder if the authors have tried the experiment so nicely illustrated on page 40. The reviewer confesses that he has and never succeeded very well. The effect of surface tension is too great for this apparatus to be very satisfactory.

The *Do You Know* paragraphs given often throughout the book are an outstanding feature for provoking thought. Much of the recitation period might well be concentrated on the discussion of such questions. Other important parts are the *Highlights*, or the essential facts that are given in condensed form at the close of each chapter, the problems in Group A and Group B, and a list of *Things to Do*. Give this text a thorough examination before selecting a new book for your class.

G. W. W.

DIFFERENTIAL EQUATIONS WITH APPLICATIONS, by Herman Betz, Paul B. Burcham, and George M. Ewing, Department of Mathematics, University of Missouri, Columbia, Missouri. Cloth. Pages x+310. 13.5×21 cm. 1954. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price $4.50.

This is a text for a first course, with emphasis upon applications rather than underlying theory. The treatment might be considered to be in the traditional fashion, although there is material on such topics as rocket flight, population growth, and relations between species, which may not be found in other texts. Definitely this is a book which seems teachable for a first course.

Features which appealed to this reviewer included: the fact that in the process of separation of the variables solutions may be lost; the section on properties of the linear equation; the treatment of symbolic operators, and an introduction to the Laplace transformation; a good, though necessarily brief, discussion of graphical and numerical methods of solution; a chapter on Fourier series and boundary value problems. There is a short discussion of partial differential equations.

Features which gave a less favorable impression were fewer. The problem lists may in places be too short if alternate assignments are desired in successive semesters. On page 16–17 the "remark" might be so phrased as to cause a student to wonder if he can place any confidence at all in an integral table, and to wonder if some other method might be available. The discussion of envelopes seems very brief, and there is very little discussion of the geometrical significance of singular solutions. Obviously the material desired in a text will vary with the objectives of the course and the viewpoint of the instructor. Definitely this text should receive consideration when an adoption is contemplated.

CECIL B. READ
Universiy of Wichita

THEORY OF FUNCTIONS OF A COMPLEX VARIABLE, Volume One, by C. Carathéodory, *Professor, University of Munich,* and Translated by F. Steinhardt, *Instructor, Columbia University.* Cloth. Pages xii+301. 14×23 cm. 1954. Chelsea Publishing Company, 552 West 181 Street, New York 33, N. Y.

Although classified in the editor's preface as primarily a textbook, this might in many respects be considered also a reference book in the theory of functions of a complex variable, suitable for graduate school work—possibly advanced undergraduates might use it. The range of material covered is greater than might be expected from the title—for example it includes such topics as non-Euclidean geometry and trigonometry; inversion geometry; Jordan curves, rectifiable curves; Benoulli numbers and the Gamma function. Those interested in the literature in the field at this level will be glad to have available an English translation. Whether the book is a suitable text in a specific course cannot be answered without investigation by the individual teacher. Certainly there is more material than would be covered in many courses, but in some instances omission could be made without destroying continuity. There are no sets of exercises.

CECIL B. READ

AN ANALYTICAL CALCULUS FOR SCHOOL AND UNIVERSITY, Volume II, by E. A. Maxwell, *Fellow of Queen's College, Cambridge, London.* Cloth. Pages vi+272. 1954. Cambridge University Press, American Branch, 32 East 57th Street, New York 22, N. Y. Price $3.50.

AN ANALYTICAL CALCULUS FOR SCHOOL AND UNIVERSITY, Volume III, by E. A. Maxwell, *Fellow of Queen's College, Cambridge.* Cloth. Pages vii+195. 13.5 ×21.5 cm. 1954. Cambridge University Press, American Branch, 32 East 57th Street, New York 22, N. Y. Price $2.75.

Volume I of this set was reviewed in SCHOOL SCIENCE AND MATHEMATICS for June, 1954. As there indicated, it is doubtful if the books would serve as a text in most of our American colleges, nevertheless a comparison of the treatment, and the extensive problem lists, would warrant placing the set in the college library. Some minor variations in terminology and notation are noted—"differential coefficient" where our texts would use "derivative;" use of "gradient" rather than "slope;" the notation $\sqrt{(a+b)}$ rather than $\sqrt{a+b}$; the decimal point in the center of the line.

Volume II opens with a treatment of logarithmic and exponential functions, starting with the definition:

$$\log x = \int_1^x \frac{dt}{t}.$$

Other topics in this volume include the hyperbolic functions, curves, (in this chapter one finds a brief discussion of coordinate systems other than cartesian or polar—intrinsic coordinates and pedal coordinates being mentioned, with a formula for curvature in pedal coordinates); complex numbers (the treatment being more extensive than usually found in our beginning calculus texts); systematic integration and integrals involving "infinity."

Volume III deals with functions of more than one variable, and has a final chapter on curve tracing. The treatment in this volume is definitely more rigorous than one finds in the usual first calculus text in the United States, and requires some mathematical maturity to read it. As a few examples of topics treated more fully than the usual first calculus text, one might mention the discussion of Jacobians (there is a discussion of the ratio of areas and of volumes under transformation); the discussion for necessary and sufficient conditions for maximum or minimum values of functions of several variables; the detailed discussion of curve sketching, including such topics as parabolic asymptotes, approximations near the origin and at distant points.

There are several nice applications of determinants, for example, the equation of the tangent to a curve when the curve is defined by parametric equations (expressed as a third order determinant); necessary and sufficient conditions for a maxima or minima of a function of three variables, expressed as determinants. Answers are provided for the majority of the exercises.

CECIL B. READ

SCHOOL FACILITIES FOR SCIENCE INSTRUCTION. John S. Richardson, *Editor*. *Committee of The National Science Teachers Association*. Cloth. 266 pages. 8½″×11″. 1954. NSTA. Washington, D. C. Price $5.50.

This is one of the most practical books in the field of Science Education published in the last few years. It's true value can only be appreciated by examining the book itself. The title, although accurate, is a bit misleading in so far as the content covers more than merely the facilities for Science Instruction. Most of it of course does revolve about the latest facilities as judged by hundreds of educators throughout the country, but in covering this subject, more method and practice is uncovered than many texts devoted exclusively to the latter areas.

The book is divided into ten chapters, each devoted to a specific field of science taught from the Elementary grades through College. The first chapter revolves about twenty major principles concerning facilities for science instruetion. These are taken in detail, without verbosity. The second is devoted to the general aspects of school facilities which are in turn carried throughout the text.

Each chapter includes many diagrams and photos of an ideal room devoted to the study of its particular branch of science viz: Chemistry, Physics etc. It also includes details of storage spaces and equipment layouts. At the end of the chapter is a check list of materials and a specific bibliography. One of the most important features, although not emphasized, is the wealth of illustrations and discussions on the kinds of activities and teaching done in the schools illustrated. The appendix includes a list of the contributors, lists of equipment and supplies, approximate costs of materials, tools, audio-visual equipment and a supplementary bibliography.

The only short coming is that which is common to hundreds of plans in many books and pamphlets viz: most of the planning is for an ideal class size of about twenty five or perhaps thirty. This may be no inspiration for those who try to model their classes after the book.

This unusual book is most urgently recommended to all connected with Science Education in any way whatsoever. Present and future administrators should consult it before planning anything that might involve their schools. Teachers in training should be required to study this volume before certification. Teachers in service ought to have this book available and examine it from time to time to compare their teaching methods and facilities, not so much to criticize their inadequate facilities but to see what they can do themselves to improve their circumstances. This cooperative effort has resulted in a publication that is a monumental stride in the field of science education. Teachers reading it, will undoubtedly hope that those who are in the position to use it will take advantage of its contribution, for the benefit of all.

JOHN D. WOOLEVER
Detroit, Michigan

CAREERS AND OPPORTUNITIES IN SCIENCE, by Philip Pollack. Cloth. 252 pages. 13×20.5 cm. 1954. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York, 10, N. Y. Price $3.75.

This unusual book presents a survey of all fields of science in a most interesting manner. In is well organized and each chapter follows along as a novel or book of short stories. Biological, chemical, geological and many other fields are discussed. Although it would be impossible to cover every scientific job, those that are included are handled extremely well.

Short historical adventures in modern science introduce each field. Occasionally a biographical sketch or the study of a modern invention leads into the careers available today. Many problems under present investigation are discussed along with some of the things living scientists and companies are trying to accomplish. The reader is taken directly into a career as he reads, and before he knows it, he has a very clear picture of the field. The many sidelights lend a realistic air of adventure to the many careers described.

A great deal of science is included. Many important principles and phenomena with practical applications demonstrate the value of class room science in all the careers. The latest available salary figures, educational requirements, institutions offering courses needed to qualify for the careers, are conveniently listed in the appendix. An excellent bibliography for further specific information is also included.

The importance of women in science is not neglected. A great deal of emphasis is placed on the accomplishments of young people, such as those who participated in Science Club activities. This is important in dispelling the notion that scientists are a lot of old hermit like characters. Many excellent photographs of scientists in action supplement and illustrate the types of activity involved in a scientific career.

This small book does an excellent selling job in behalf of science careers. It should be on every school library shelf and suggested reading lists for students above the seventh grade. Science teachers and Counselors should read this book to enable them to speak intelligently of the opportunities available for those who might have the slightest inclination towards a career in any science field.

JOHN D. WOOLEVER

SCIENCE THE SUPER SLEUTH, by Lynn Poole, *Producer of The Johns Hopkins TV Science Review*. Cloth. 192 pages. 14×20.5 cm. 1954. Whittlesey House, McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $2.75.

"These Science guys have ruined our chances." is the general theme implied by this collection of crime and detection stories. This little book reads like a summary of condensed television stories based on local police files, sans the commercials.

There are about six main detecting methods with as many scientific instruments used by the modern crime laboratory, described herein. Each is shown to be a determining factor in the apprehension of an actual criminal. These methods include density gradient, polygraph, spectrograph, microscope, fluoroscope and the Geiger Counter. The remaining practices such as blood typing, fingerprinting, fluorescence and casting also are used to demonstrate the methods of criminalistics.

Each chapter revolves about one of the afore mentioned subjects as it applied to a specific crime or criminal. The style of writing is clear and easy to follow. Explanations of methods and instruments are simple and the sketches although rather crude, supplement the descriptions.

The most distinctive chapter that hasn't been done by most comic strips is that which relates the difference between a penthouse fall, push and suicide. The difference being that of trajectory.

Although a nationally known author of mystery fiction believes the book should be required reading for every lawyer, it is little more than light reading for teen agers and could be considered as an expanison of Dick Tracy's "Crime Stoppers."

It does show how some applications of scientific principles aid in crime detection, but perhaps more substance might have been included in the same space. It has no objectionable material in it and will probably appear on most school library reading lists. Most teen age general students would find it interesting reading over a week end.

JOHN D. WOOLEVER

GENERAL SCIENCE, by Victor C. Smith and W. E. Jones. Cloth. 504 pages. J. B. Lippincott Company, Chicago, 1955.

GENERAL SCIENCE WORKBOOK, by Victor C. Smith and W. E. Jones. Paper. 192 pages. J. B. Lippincott Company. Chicago, 1955.

This new ninth grade science text is good for those classes that are known to be terminal courses for the students in them. It is divided into nine units, each averaging fifty pages. There are about eight demonstrations in each unit, answering the questions that center about the unit topics. The units are evenly divided between the various biological, and physical sciences, chemistry, geology, etc. that are in the typical general science texts.

The pictures illustrate the experiments and demonstration set-ups along with hundreds of applications of the related phenomena discussed. The author state that the vocabulary is based on major studies in the field, but at times it appears that the words might prove difficult to those below that "average student." Occasionally some of the sentences are rather complex, but in general they are short and to the point. Each paragraph is designed to answer a question preceding it.

At the end of each demonstration, a short paragraph titled "What we learned" leads the student to summarize his observations. If these findings are meant to answer the questions revolving about the demonstration, there is some very complex reasoning involved in some cases. The answers are not as simple as the questions.

The photographs are very good but some are in startling solid colors. There is a photograph or diagram on almost every page with good descriptions below each. Word lists are abundant, as well as completion exercises and special problems.

At the end of each unit, there is a review. This includes a summary, an exercise on the principles covered, additional problems and a short bibliography of fiction and nonfiction for the student. An extensive glossary and index completes the text.

The accompanying workbook is also designed for a year course and is actually just as useful with other texts in General Science. There are eighty-one lesson exercises designed for either one or two days of class work, in or out of the laboratory. There are more than twice that number of experiments and demonstrations.

A short stimulating paragraph introduces each lesson. The experiment follows and that in turn is followed by several questions based on the activity. This pattern is like the text. Each has a list of useful words and a set of objective review questions that are easy to correct.

Occasionally diagrams of the apparatus set up are included in the lessons. One of the most important features of the manual however, is the space devoted to the principles and their practical applications. There are several pages devoted entirely to summary and review questions.

For those who might use the workbook with other texts, there are listings of the pages corresponding to most of the latest General Science texts.

JOHN D. WOOLEVER

THE EARTHWORM. THE FROG. THE HUMAN, by Dr. Albert Wolfson, *Associate Professor of Biology, Northwestern University*, and Arnold Ryan, *Scientific Illustrator, Evanston, Illinois*. Unitexts in biological science. Paper, $6\frac{1}{4} \times 9\frac{1}{2}$ inches. 1955. Pages: 34 in *The Earthworm* and *The Human;* 26 in *The Frog*. Row, Peterson and Company, 1911 Ridge Avenue, Evanston, Illinois. $3.20 each.

Each of these booklets contains four acetate pages (eight sides) of drawings illustrating the external and internal features of its specific subject, in realistic color and good perspective. By turning the pages, the viewer can easily dissect his specimen wherever and whenever he wishes. Each anatomical part is keyed for identification.

The remaining few pages of each booklet are filled with some diagrams and short descriptions of the various systems, how they work and how they are related to the other systems in the body. Some of the diagrams are rather over-simplified, but this is rectified by the acetate illustrations. The entire content is no more than what might be found in a good terminal General Science textbook, except for the featured transparencies. There is no index, glossary or table of contents although some of the new words are pronounced as they are met in the descriptions.

The heavy gloss paper is stapled, and the inside covers include diagrams of the animal's systems and life cycle. It is unfortunatel that the cost of these unitexts prevents their use on a large scale in the average high school biology class. However, they would be valuable additions to the school library or as supplementary material for the college zoology student who could afford them. Perhaps sometime in the future this "new dimension" will be a common sight in all biology texts and laboratory manuals.

JOHN D. WOOLEVER

TRIGONOMETRY, by William L. Hart, *Professor of Mathematics, University of Minnesota, Minneapolis, Minnesota*. Cloth. Pages vi+230+130. 14.5×22.5 cm. 1954. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $3.75.

This text differs from the 1951 *College Trigonometry* by the same author in that it begins the course with the trigonometry of acute angles before presenting the general angle. The latter topic is introduced in Chapter Four. Materials beyond this chapter are identical with the author's 1951 edition.

The text presents a substantial treatment of plane and spherical trigonometry and incorporates modern viewpoints as to content and emphasis. The sections on analytic trigonometry are emphasized and are directed toward latter needs in mathematics. Applied problems are varied and up to date. The author's usual extensive logarithmic and trigonometric tables have been augmented by a new six page table of haversines and their logarithms.

Line values of the trigonometric functions are discussed briefly in the appendix. No unit circle problems are included in the main body of the text. Attention is given to significant digits and computation with approximate data, and answers are given in rounded form after the discussion has been presented.

The book is designed for a substantial semester course for either advanced students at the secondary level or to typical freshmen at the college level. Teachers who already like the materials of the author's 1951 edition, but prefer to begin their course work with the functions of acute angles, will welcome this new addition to the well-known series written by the author.

REINO M. TAKALA
Hinsdale Township High School
Hinsdale, Illinois

NORTH CENTRAL CONFERENCE ON BIOLOGY TEACHING

A North Central Conference on Biology Teaching sponsored by the National Association of Biology Teachers on a grant from The National Science Foundation, will be held at the University of Michigan Biological Station at Douglas Lake, Cheboygan, Michigan, August 19–30, according to Brother Charles H. Severin, President of NABT, St. Mary's College, Winona, Minnesota.

Ninety delegates will be selected from high schools, colleges and state departments of education in Michigan, Ohio, West Virginia, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri and Kansas.

This is the second conference sponsored by NABT and The National Science Foundation. The Report of the Southeastern Conference held in 1954 at the University of Florida, was published as the January issue of *The American Biology Teacher*. Single copies are available from Paul Webster, Secretary-Treasurer, NABT, Bryan High School, Bryan, Ohio.

A LETTER FROM COOS BAY PUBLIC SCHOOLS

Dr. Paul B. Jacobson, Dean
School of Education
University of Oregon
Eugene, Oregon

Dear Dean Jacobson:

Your speech at our mid-winter meeting was very excellent and I was right with you until you decried the lack of Marine Biology instruction in the schools of our coast towns.

Sir, I am the father of a sophomore at Marshfield High School. My daughter is enrolled in Biology, and so, in a more or less vicarious manner, is our whole family.

For the past month, life at our house has revolved around a heinous thing called a *Term Project*. At first hearing a *Term Project* has relatively simple requirements. The bulletin says, "Mount and classify 10 marine animals." This could easily be done in one afternoon. Simply go to the beach, pick up ten different small animals, place them in plastic jars of formaldehyde, type out their classification and glue them on a display board . . . nothing difficult at all.

Complications arose when competition, which is rife in this school, reared its head. When the first eager student turned in her project, everyone saw that it contained and decided that their project must be more extensive and/or contain rarer specimens. For instance, Sally decided that her featured specimen would be a Blenny, (*Epigeichthys, atropurpureus*). Life stood still in our household until one great day the elusive little fish was captured. The joy occasioned by this great acquisition turned to bitterness when not one, but *five* Blennys turned up in other collections the very next day.

You can imagine how things are in this area with 270 kids and their families scouring the mud flats, the rocks and the beaches for rarer and rarer species. Sally found a 22 armed starfish (*Asterias vulgoris*), Sunday afternoon and I am willing to settle on that as a centerpiece in her collection, but she now has her heart set on an octopus (*Octupus bimaculatus*), and she figures if this brewing storm is heavy enough it will bring some in. She plans to pickle it in a wash tub.

Our house has reeked with formaldehyde and specimens in various stages of ripeness for some weeks. I can detect the odor of decaying sea-life in everything I eat or wear. My friends no longer sit near me at Rotary; I am sure that people turn and look at me as I walk down the street.

The two fanatical instructors who brought all this on are having some difficulties too, which they certainly deserve. Each has about 135 students and each instructor spends three or four hours every evening evaluating projects, wrong or phony classifications, and answering phone calls from distraught parents who are sure Willie has been drowned. Since the projects are mounted on pieces of plywood, they occupy considerable space. Their classrooms are over-run, cluttered, and odorous. Their professional stature suffers when a 15 year old Biologist, copy of *Between Pacific Tides* in hand, says, "You said this was a *Hemigrapsus nodus*. This book says its a *Pachygrapsus crassipes*. Look, right here. . . ."

I have no sympathy for them, and all I really meant to say to you was that if any school is doing more in Marine Biology than we are I don't want to be principal of it, nor do I want to be a parent of one of its students.

Odorously yours,

GUY SHELLENBARGER, *Principal*
Marshfield Senior High School

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